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PROGRAM OFFICE, ABZRA.

DOCUMENT NO. D2-80065

UNCLASSIFIED TITLE Aerodynamic Stability and Control

Data Model 844-2050.

MODEL NO. Dyna Soar CONTRACT NO. AF33(600)-41517

ISSUE NO. 92 ISSUED TO AFJNA

CLASSIFIED TITLE
(STATE CLASSIFICATION)

WORK ORDER NO.

UNIT NO.

ITEM NO.

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USAF and NASA
review(s) completed.

NO. OF PAGES 191 (EXCLUDING TITLE AND REVISION AND ADDITION PAGES.)
COMPLETE REVISION 358 PAGES

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ID 61RWRS-12069

12-20-61

BAC 324 B-RB

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REV	REVISED	ADDED	DELETED	REV	REVISED	ADDED	DELETED	REV	REVISED	ADDED	DELETED
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12-20-61						BOEING AIRPLANE COMPANY					
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						P NO. 3					

REVISIONS

12-20-61

Revised to update the aerodynamic stability and control data due to changes in configuration.

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12-20-61

U3-4071-1000 (was BAC 1646-L-R3)

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NO. D2-80065

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12-20-61

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1.0 INTRODUCTION

This document is prepared in fulfillment of the requirements of paragraph B(1.1.1.1.3.1) of the Statement of Work, System 620A Dyna Soar (Step I), Exhibit 620A-61-28, dated 1 September 1961. The purpose of this document is to present the current status of the Dyna Soar glider's stability and control aerodynamic characteristics.

The contents include static and rotary force and moment coefficients, trim characteristics, control surface hinge moments, limited effects of flexibility and thermal deformation and aerodynamic performance characteristics. Limited data is also presented on the glider and abort vehicle in the presence of the air carrier.

The purpose of this document has also been broadened to the extent that it becomes the primary vehicle of aerodynamic data and flight constraints for flight control subsystem design and simulator design. New data sections including performance, constraints due to aerodynamic heating and loads, and glider aerodynamic characteristics in the presence of the air carrier for drop tests have been added to fulfill the documents broader objectives.

Significant changes have been made in the glider and abort vehicle aerodynamic configuration to warrant a complete revision of this document. These changes are described in detail in Section 3 "Configuration Description". Time has not permitted complete wind tunnel test verification over the flight regime of the latest configuration.

Periodic revisions to this document are scheduled for the future. Additions and revisions to the data presented will be made at these times pending the results of additional wind tunnel data and analysis.

2.0

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BTWT 655	D2-80298 Data Report, 655 Transonic Speed Test of the Dyna-Soar Glider
BTWT 672	D2-80494 Unreleased Document
BTWT 680	No document number or title at this date.
BTWT 682	No document number or title at this date.
BTWT 685	No document number or title at this date.
BSWT 105	D2-80347 Unreleased
BSWT 113	D2-80407 Unreleased
BSWT 113B	D2-80492 Unreleased
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BAC 21	D2-80418 Unreleased document.

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CONFIDENTIAL**3.0 CONFIGURATION DESCRIPTION****3.1 CONFIGURATION DESCRIPTION - GLIDER**

A three view drawing of the model 844-2050 Revision D glider is presented in Figure 3.1. The glider is shown in the cold shape or jig condition as would exist prior to re-entry. A photograph of an .067 scale model of this configuration is shown on Figure 3.2.

Features significant to the stability and control characteristics are discussed in the following paragraphs.

The wing is essentially triangular in planform with a leading edge sweep angle of $72^{\circ} 48'$.

The lower surface of the wing is a flat surface with a positive nose incidence of 3° occurring at Body Station 299.00. Thermal deformation will increase this nose bend up to approximately 4° . The clearance between the outboard edge of the elevon and the rudder actuator housing has taken the form of a tapered gap. This gap has been minimized to allow maximum longitudinal stability in the subsonic-transonic regime while still satisfying the thermal expansion requirements for clearance at hypersonic speeds.

The forebody nose contours have the greatest destabilizing effect in yaw. These contours are determined from aerodynamic considerations, structural, space, and visibility requirements. A ramp, commencing at Body Station 388.5 and expanding to a thickness of 12.0 inches at the aft end of the body, has been added to the top surface of the body. This ramp produces a positive C_{mo} shift and a reduction in elevon hinge moments at low supersonic speeds. This ramp has also a favorable effect on transonic directional stability. The APU exhaust ports are relocated on the ramp.

A probable critical temperature problem innate to the previous cab-heatshield design has required a modification of these parts. The changes have essentially raised the top portion of the heatshield and replaced the radial fairing between the top and front of the cab with a flat surface.

The speed brake has been deleted. Studies have revealed that the simultaneous outboard deflection of the rudders will provide the necessary braking effect.

The vertical tail must provide an efficient lifting surface and yet be of minimum dimensions for weight, drag, structural, and thermal requirements. The existing planform of 844-2050 D glider has an area of 31.3 ft.² per side with a 55° leading edge sweep. The tail is located as far aft of the center of gravity as structurally possible for static directional stability and on the wing tips to minimize wing and body interference. The tails are canted inboard

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5.1

CONFIGURATION DESCRIPTION - GLIDER (Cont'd)

at an angle of $9^{\circ} 56'$ to give increased directional stability through small angles of sideslip at hypersonic speeds.

A significant change in the vertical tail for this configuration is the increased thickness of 8.0 inches. The leading edge of the fin is made up of a 3.0 inch radius which satisfies the heating design requirement, and a flat surface required to complete the 8.0 inch thickness. However, this "radius-flat" leading edge fairs into a 4.00 inch radius leading edge at the rudder.

Physical dimensions of the actuators have required the enlargement of the rudder actuator housings. Other modifications, primarily required for heating and clearance requirements, are the 4.0 inch radius on the upper fin at the rudder hinge line and a 20.0 inch radius on the lower rudder at the hinge line.

The rudders will be trailed inboard $6^{\circ} 0'$ from the faired position to reduce hinge moments for the subsonic through low supersonic speed range. To obtain the directional stability required at higher speeds, the rudders will be in the faired position as shown in Figure 3.1. The position of the rudder trail will be controlled by the pilot. The rudders will be deflected together and will be capable of 35° outboard and 12° inboard deflection.

Aerodynamic control about the pitch and roll axis is provided by the trailing edge elevons. The elevon planform has been influenced by several design considerations. The inboard edge is determined by structural and space requirements. The sweep and radius of the outboard edge and leading edge are determined by aerothermodynamic limits and by the rudder actuator housing. The trailing edge and sweep has been determined by planform studies of sweep angle for best stability. The elevons have the hinge lines normal to the plane of symmetry of the vehicle. The trailing edges are swept $10^{\circ} 28'$. The outboards edges have been modified to obtain a minimum gap and to conform to the enlarged rudder actuator housing. These boundaries have produced a total elevon area of 46.0 ft.^2 with a minus $10^{\circ} 0'$ wedge cross section.

The elevons provide the glider with adequate pitch control to trim and maneuver the glider. The differential use of the elevons provides the necessary roll control. The elevons must also provide adequate control moments for augmentation as required by the Flight Control System. The deflections of the elevons are 55° up and 16° down at a deflection rate of $20^{\circ}/\text{sec.}$ under no load.

The glider landing gears, equipped with uncooled all-skid surfaces, utilize the tricycle arrangement. All three struts and skids retract

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NO. D2-80065

CONFIDENTIAL**3.1** CONFIGURATION DESCRIPTION - GLIDER (Cont'd)

forward for storage. The gear is extended by a gas system with aerodynamic assist. The rate of extension is controlled by the snubbing action of the gas actuators. No sequencing of the gear is currently planned during extension.

The reaction control system used for control during orbital flight and for augmenting the aerodynamic control surfaces in the upper atmosphere are powered by a H_2 and O_2 fueled hot gas system. Pilot control inputs are accomplished through the sidestick controller when the stick deflection exceeds a predetermined dead band. These inputs operate on-off valves at the reaction nozzles. The reaction nozzles are located on the glider to give control about the three vehicle axes. The pitch up nozzles are atop the body and aft at Body Station 450.0. The pitch down nozzles are on the lower surface of the actuator housing at Body Station 473.67. The roll nozzles are on the upper surfaces of the wing at Body Station 355.3 and Buttock Line 72.0. The yaw nozzles are near the aft end of the body at Body Station 452.3 and Water Line 124.3.

A more detailed description of the configuration and systems is included in Reference Number .

3.2 THIRD STAGE CONFIGURATION

The glider and booster are integrated into an overall flight vehicle by means of a transition section which serves as the structural connection and aerodynamically smooth fairing between the booster and glider. The transition section general arrangement is shown in Figure 3.1 .

The glider abort and air launch system consists of the glider plus transition section which contains the acceleration rocket. To achieve additional control during abort, the thrust vector control of the acceleration rocket is used along with the aerodynamic controls.

The acceleration rocket is a solid propellant rocket with a propellant weight of 2200 pounds. The four nozzles are all hinged and located with centers on 45 diagonals in the rear view. They may be all used in pitch, yaw, roll or combinations required.

3.3. WEIGHTS AND MOMENTS OF INERTIA

The design weights and moments of inertia for the glider vehicle are presented below.

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3.3 WEIGHTS AND MOMENTS OF INERTIA

For the glider alone (transition section off):

Weight = 10000 lbs.

Principle moments of inertia about C.G.:

$$\begin{aligned} I_y &= 19,229 \text{ slugs} - \text{ft}^2 \text{ (pitch)} \\ I_x &= 4378 \text{ slugs} - \text{ft}^2 \text{ (roll)} \\ I_z &= 22,103 \text{ slugs} - \text{ft}^2 \text{ (yaw)} \end{aligned}$$

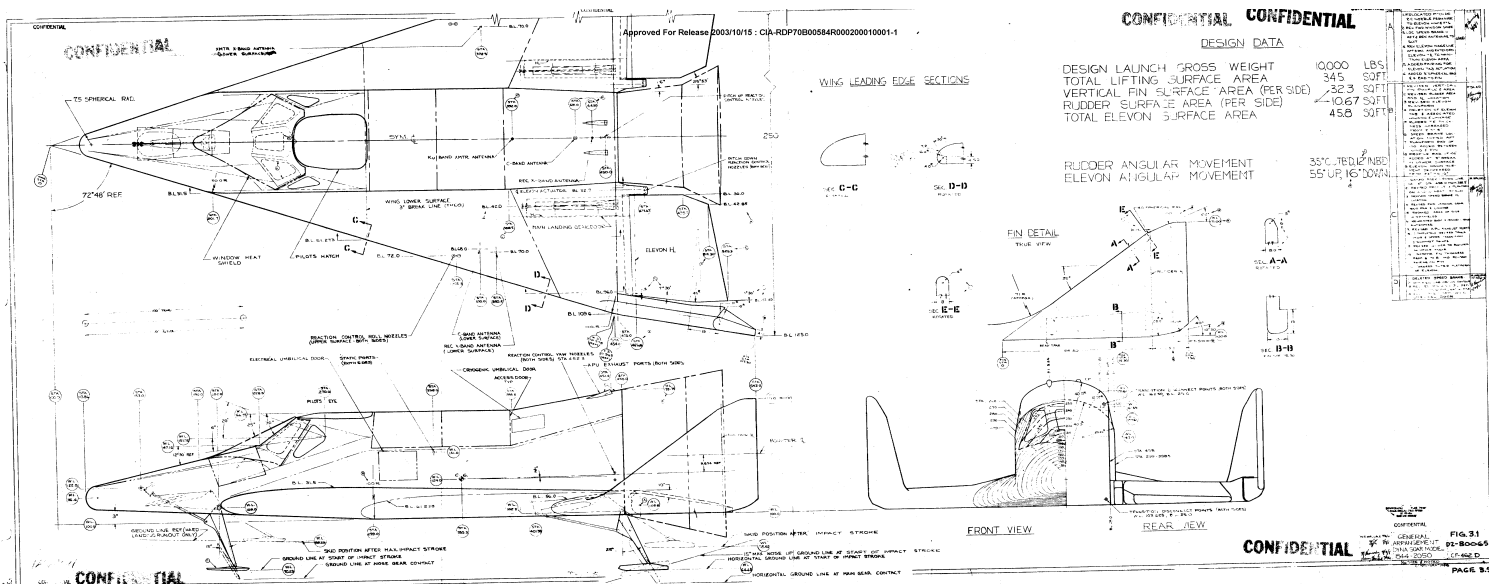
The nominal center of gravity for the glider alone is at Body Station 355.3 and Water Line 124. See Figure 3.1.

For the 10000 lb. glider plus third stage, Figure 3.3 gives the moments of inertia, gross weight, and center of gravity from the beginning to the end of third stage burning.

3.4 AERODYNAMIC DATA AND REFERENCE CONSTANTS

Aerodynamic data in the document are presented on a fixed body axis system. The axis system is shown on Figure 3.4. Definition of angle of attack and sideslip and the sign convention for the force and moment coefficients are also shown. The sign conventions for control deflections are shown on Figure 3.5.

Reference constants and glider alone center of gravity location are shown on Figure 3.6. Some significant aerodynamic configuration constants are also presented.

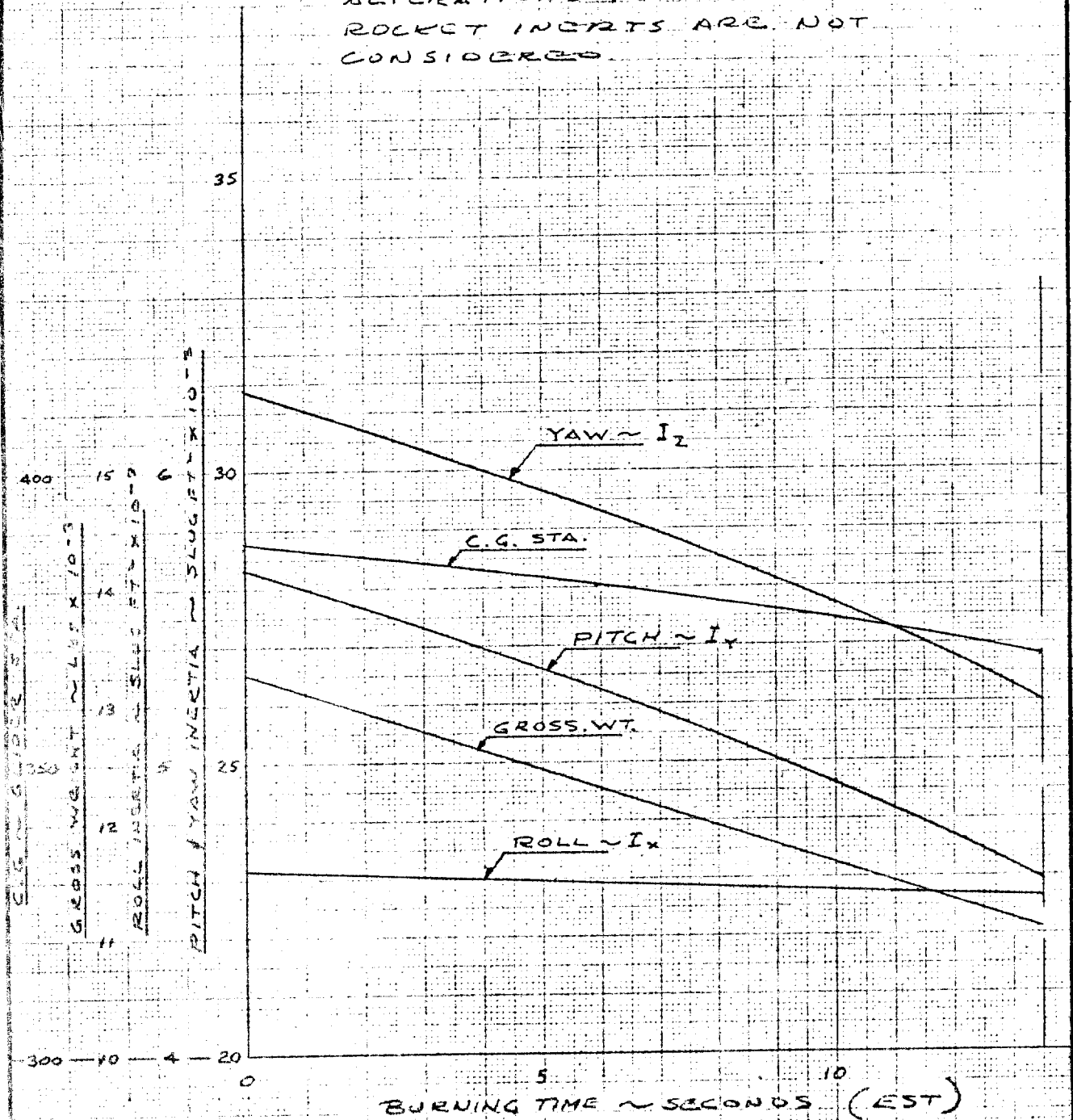




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DATA IS DERIVED FROM PREVIOUS
MASS DATA CONSIDERING ONLY
THE REDUCTION OF 1000 LBS.
PROPELLANT. CHANGES DUE TO
ALTERATIONS IN TRANSITION AND
ROCKET INERTS ARE NOT
CONSIDERED.



CALC	bwR	1/24/61	REVISED	DATE	EST. MASS DATA
CHECK					GLIDER + 3 RD STAGE
APR					(2200 # PROPELLANT)
APR					

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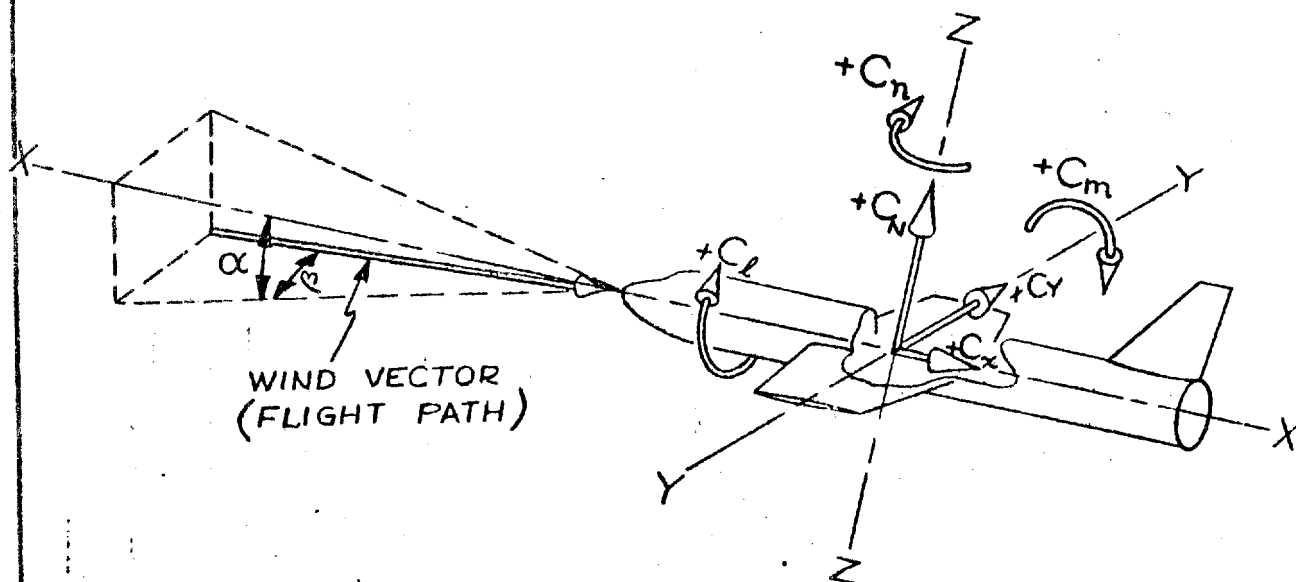
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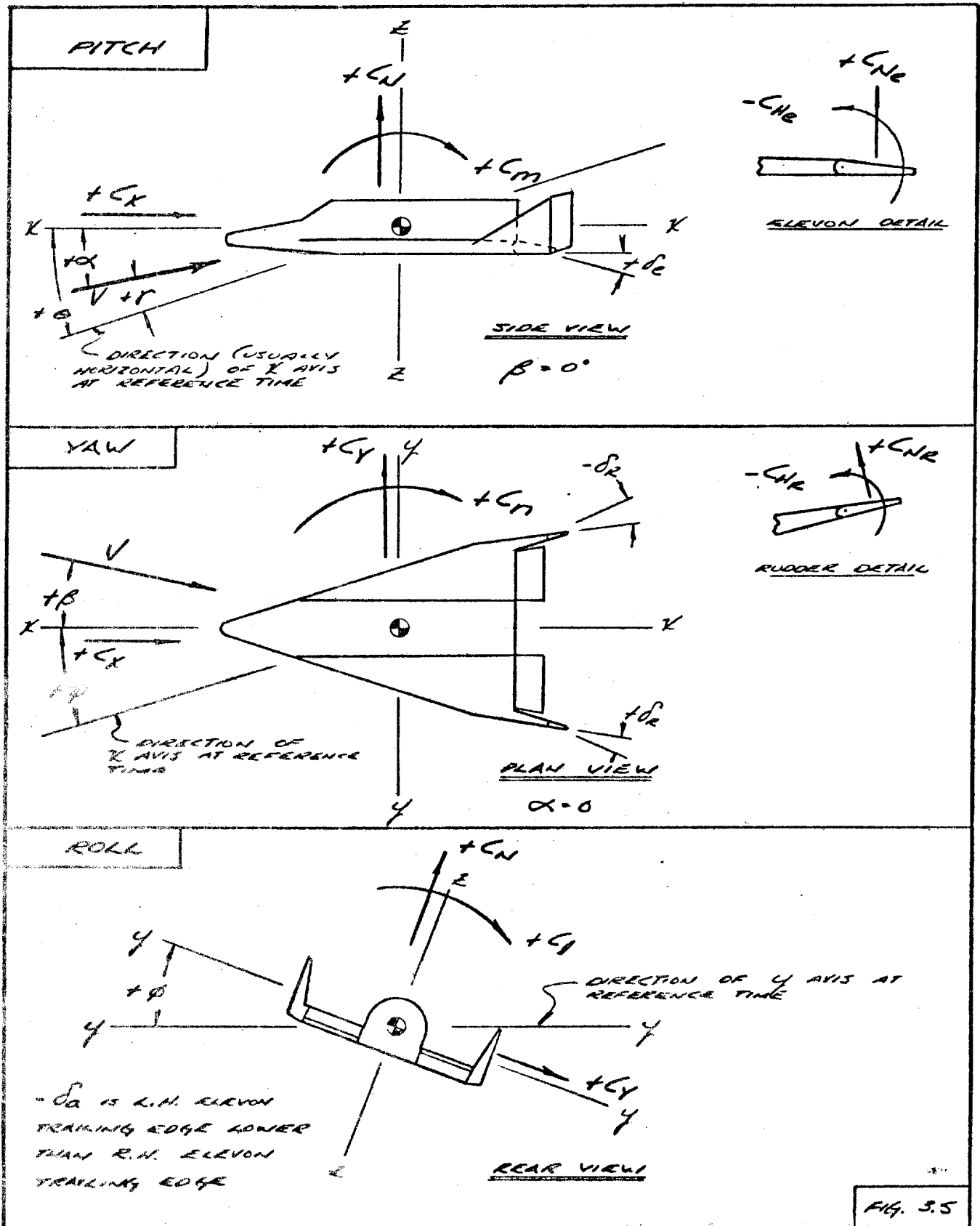


NOTES:

- 1) THE MUTUALLY PERPENDICULAR X, Y, AND Z AXES ARE FIXED ON THE AIRPLANE, REGARDLESS OF FLIGHT ATTITUDE.
- 2) ANGLE OF ATTACK IS MEASURED IN THE AIRPLANE PLANE OF SYMMETRY (X-Z PLANE), BETWEEN THE AIRPLANE X-AXIS AND THE PROJECTION OF THE WIND VECTOR INTO THE X-Z PLANE.
- 3) ANGLE OF SIDESLIP IS MEASURED IN OR PARALLEL TO THE PLANE DEFINED BY THE AIRPLANE Y-AXIS AND THE WIND VECTOR, BETWEEN THE WIND VECTOR AND THE PROJECTION OF THE AIRPLANE X-AXIS INTO THE ABOVE-DEFINED PLANE.
- 4) FOR THE DYNA SOAR 844-2050 CONFIGURATION, THE X-Y PLANE IS PARALLEL TO THE FLAT, AFT PART OF THE WING UNDERSURFACE.

FIG. 3.4

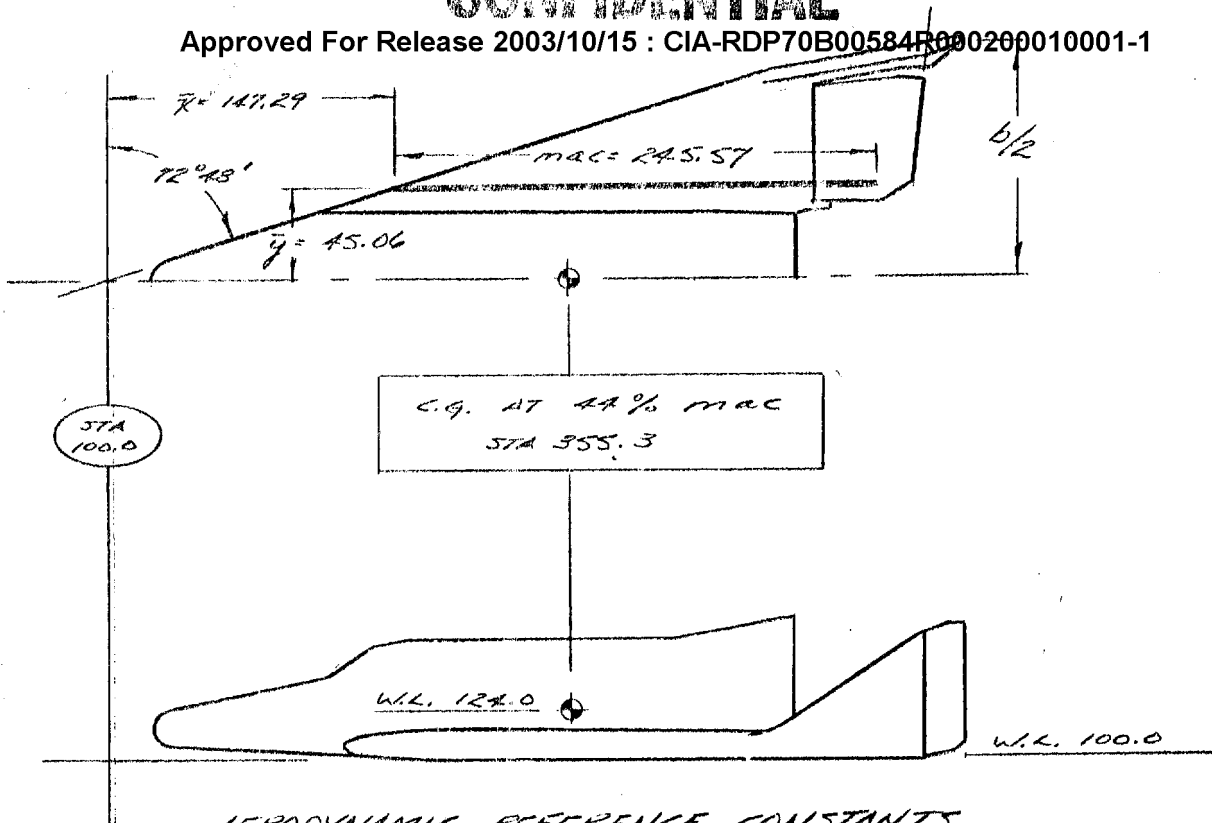
CRDC			REVISED	DATE	BODY AXIS SYSTEM NOMENCLATURE ~ COMBINED ANGLE OF ATTACK & SIDESLIP	844-20500
CHECK			12-2-61			02-80065
APR						
APR					BOEING AIRPLANE COMPANY	PAGE 3.8
DWN	M. CARTER	12-28-0				



CALC			REVISED	DATE	BODY AXIS SYSTEM NOMENCLATURE	844 2050 0
CHECK			SAUNDERS	12-11-1		
APR				12-28-1		DL-80065
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Drawn	CHARTER	12-27-1				

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AERODYNAMIC REFERENCE CONSTANTS

S_w , WING AREA 345 FT.²
 MAC , MEAN AERODYNAMIC CHORD 245.57 IN.
 b , SPAN 245.48 IN.
 AR , ASPECT RATIO 1.21

VERTICAL TAIL

S_{VT} , TAIL AREA (AIRC SIDE) 31.3 FT.²
 S_{VT}/S_w , BOTH SIDES 0.182
 l_{VT} 148.88 IN.
 $\bar{V}_{VT} = \frac{S_{VT} l_{VT}}{S_w b}$, BOTH SIDES, 0.110

RUDDER

S_R , RUDDER AREA (PER SIDE) 10.6 FT.²
 S_R/S_w , (BOTH RUDDERS) 0.061
 l_R 175.5 IN.
 $\bar{V}_R = \frac{S_R l_R}{S_w b}$, (BOTH RUDDERS) 0.044
 $2M_R$ 245 IN.-FT.²

ELEVON

S_E , TOTAL ELEVON AREA 46.0 FT.²
 S_E/S_w , TOTAL AREA 0.133
 l_E 138.3 IN.
 $\bar{V}_E = \frac{S_E l_E}{S_w b}$, TOTAL AREA 0.075
 $2M_E$ 1195 IN.-FT.²

CALC	SWATA	12.15.1	REVISED	DATE	AERODYNAMIC REFERENCE CONSTANTS	FIG. 3.6
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APR						02-80065
APR					BOEING AIRPLANE COMPANY	PAGE 3.10

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4.0 DEFINITION OF SYMBOLS

a.c.	aerodynamic center
A/F	airframe
b	wing span
B.L.	buttock line
B.S.	body station
c.g., C.G.	center of gravity
C_D	drag coefficient
δ_{eL}	left rudder deflection
δ_{eR}	right rudder deflection
W_p	weight of acceleration rocket propellant
W	glider weight
q, \bar{q}, Q	dynamic pressure
M	Mach number
I_x	moment of inertia about x axis
I_y	moment of inertia about y axis
I_z	moment of inertia about z axis
$C_{H\beta}$	$\partial C_H / \partial \beta$
$C_{H\delta_e}$	$\partial C_H / \partial \delta_e$
$C_{H\alpha}$	$\partial C_H / \partial \alpha$
C_{H0}	hinge moment coefficient at $\alpha = 0^\circ, \delta_e = 0^\circ, \delta_R = 0^\circ, \beta = 0^\circ$
C_{He}, C_{Hc}	elevon hinge moment coefficient
C_{HR}, C_{Hr}	rudder hinge moment coefficient
g, G	acceleration due to gravity
n, g	load factor = $\frac{\text{lift}}{\text{weight}}$
V	resultant wind velocity or free stream velocity
W.L.	water line

\bar{c} or m.a.c.

C_L

C_m

C_{m_0}

$C_{m\dot{\alpha}}$

$C_{m\alpha}$

$C_{m\dot{\alpha}}$

$C_{m\delta_a}$

$C_{m\delta_e}$

C_n

$C_{n\dot{p}}$

C_{nr}

$C_{n\delta_a}$

$C_{n\delta_R}$

$C_{n\beta}$

$C_{n\dot{\beta}}$

C_N

$C_{N\alpha}$

$C_{N\dot{\alpha}}$

$C_{N\delta_a}$

$C_{N\delta_e}$

C_{Nq}

C_x

C_y

$C_{y\beta}$

$C_{y\dot{\beta}}$

mean aerodynamic chord

lift coefficient, $\frac{L}{q S_w}$

pitching moment coefficient, $\frac{M}{q S_w \bar{c}}$

pitching moment coefficient at zero lift

$$= \partial C_m / \partial (\dot{\alpha} \bar{c} / 2V)$$

$$= \partial C_m / \partial \alpha$$

$$= \partial C_m / \partial (\dot{\alpha} \bar{c} / 2V)$$

$$= \partial C_m / \partial \delta_a$$

$$= \partial C_m / \partial \delta_e$$

yawing moment coefficient, $\frac{N}{q S_w b}$

$$= \partial C_n / \partial (\dot{p} b / 2V)$$

$$= \partial C_n / \partial (r b / 2V)$$

$$= \partial C_n / \partial \delta_a$$

$$= \partial C_n / \partial \delta_R$$

$$= \partial C_n / \partial \beta$$

$$= \partial C_n / \partial (\dot{\beta} b / 2V)$$

normal force coefficient, $\frac{N}{q S_w}$

$$= \partial C_N / \partial \alpha$$

$$= \partial C_N / \partial (\dot{\alpha} \bar{c} / 2V)$$

$$= \partial C_N / \partial \delta_a$$

$$= \partial C_N / \partial \delta_e$$

$$= \partial C_N / \partial (\dot{\alpha} \bar{c} / 2V)$$

axial force coefficient, $\frac{X}{q S_w}$

side force coefficient, $Y / q S_w$

$$= \partial C_Y / \partial \beta$$

$$= \partial C_Y / \partial (\dot{\beta} b / 2V)$$

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S_e or S_E	elevon area
S_r or S_R	rudder area
S_t	wing tip extension area
S_w	wing area
V	velocity
X	force along X (roll) axis
Y	force along Y (pitch) axis
α	angle of attack
α_{0L}	angle of attack at zero lift
β	angle of sideslip
δ_a	aileron deflection angle = $\frac{\delta_{e_R} - \delta_{e_L}}{2}$
δ_{e_L}	left elevon deflection angle
δ_{e_R}	right elevon deflection angle
δ_e or δ_E	elevon deflection angle, elevons deflecting together
δ_R	rudder deflection angle
θ	pitch angle
ϕ	roll angle
ψ	yaw angle
λ	wing taper ratio $\frac{c_t}{c_r}$
C_l	rolling moment coefficient, $\frac{l}{q S_w b}$
C_{l_p}	= $\partial C_l / \partial (pb/2V)$
C_{l_r}	= $\partial C_l / \partial (rb/2V)$
C_{l_β}	= $\partial C_l / \partial \beta$
$C_{l_{\dot{\beta}}}$	= $\partial C_l / \partial (\dot{\beta} b/2V)$
$C_{l_{\delta a}}$	= $\partial C_l / \partial \delta_a$
$C_{l_{\delta R}}$	= $\partial C_l / \partial \delta_R$

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$C_{Y\delta a}$

$C_{Y\delta r}$

C_{Yp}

C_{Yr}

C_h

$C_{h\alpha}$

$C_{h\delta e}$

$M_a = \int y da$

$$= \partial C_Y / \partial \delta a$$

$$= \partial C_Y / \partial \delta r$$

$$= \partial C_Y / \partial (pb/2v)$$

$$= \partial C_Y / \partial (rb/2v)$$

hinge moment coefficient, $\frac{HM}{q S_e c_e}$

$$= \partial C_h / \partial \alpha$$

$$= \partial C_h / \partial \delta e$$

Moment area of the control surface
aft of the hinge line.

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5.0 CONSTRAINTS DUE TO AERODYNAMIC HEATING AND LOADS

5.1 INTRODUCTION

Various constraints are placed upon the glider and air vehicle performance by aerodynamic heating and/or loads. Generally, these constraints take the form of a lower limit in allowable altitude at a given velocity and vehicle attitude. Such limits may result from

- (a) Temperature limit capability - a function only of aerodynamic heating rate, surface emissivity, maximum allowable temperature, and thermal storage. (The effect of thermal storage is very small for most Dyna-Soar conditions.)
- (b) Combined temperature/load limit capability - same as (a) except allowable temperature depends on local pressure.
- (c) Structural load factor capability.
- (d) Panel flutter characteristics.

There are two general classes of limits: basic limits, which define the altitude-velocity-attitude region in which the vehicle can operate, and control surface limits, which primarily define the allowable control surface deflection limits at a given flight condition. Basic limits are given in Section 5.2 and control surface limits in Section 5.3.

5.2 BASIC LIMITS

Glider limits for zero control surface deflection are shown in Figures 5.1 through 5.3. Limits are applicable to three phases of flight, 1) boost, 2) reentry and 3) abort conditions after separation. As such, they define minimum allowable altitude for a given Mach number or velocity as a function of vehicle attitude.

Limits imposed during boost (Figure 5.1) have been evaluated under static conditions and define maximum structural load capability of the air vehicle for the Mach numbers indicated. During higher speed phases of boost, the glider limits given below must not be exceeded. Limits due to booster case heating are transient in nature, requiring evaluation for each specific trajectory, and consequently are not shown.

Limits imposed during reentry (Figure 5.2) are based on panel flutter characteristics and structural load factor capability at

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velocities from 1000 fps to 3000 fps. The limit is defined by combined temperature/load limit capability of the vehicle from a velocity of 4000 fps through 16,000 fps. Above 16,000 fps, steady state allowable temperatures define the limit which are a function only of aerodynamic heating surface emissivity and maximum allowable temperature.

There are no constraints imposed on the air vehicle at the initiation of abort except those limits imposed during normal boost. However, boost cannot be initiated in a manner that would cause the glider to penetrate the recovery ceiling or the basic reentry limits shown in Figure 5.2 and/or 5.3.

Limits of the glider and transition section after abort has been initiated and separation occurred is shown in Figure 5.3. Structural capability is that limited by load factor, flutter and thermal considerations, whichever is the most restrictive.

5.3 CONTROL SURFACE LIMITS

Steady state control surface limits are given for unyawed flight in Figures 5.4 through 5.20 (elevons) and Figures 5.21 through 5.29 (rudders). Limits are shown in terms of minimum allowable altitude for given velocity, vehicle attitude for given velocity, vehicle attitude, and control surface deflection; conversely, they may be interpreted as maximum allowable control surface deflection for given flight condition and vehicle attitude.

Limits shown are based on steady state equilibrium skin temperatures only, and are determined by upper and lower elevon surfaces, respectively, for up and down elevon deflection, and by the rudder outboard surface. No reduction in temperature capability due to loads has been included, nor any allowance for thermal storage effects.

Upper elevon surface material characteristics are such that a certain amount of transient capability is provided; that is, the steady state up-elevon deflection limits may be exceeded for limited periods during transient maneuvers.

Little transient capability is provided by surface material characteristics of the lower elevon and outboard rudder surfaces. The effect of loads and transients will be included in future revisions.

Basic glider limit lines shown in Figure 5.2 are repeated as the lower envelope of the control surface lines of Figures 5.4 through 5.29. Also shown for comparison purposes are the glider limit altitudes based on maximum allowable temperature only, neglecting loads.

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Adjustments to rudder deflection limits for the effect of sideslip are made with the aid of Figures 5.30 through 5.33, in which the deflection limits including sideslip are presented as a function of zero-sideslip limits. As the effect of sideslip varies with angle of attack, plots are presented for $\alpha = 17.5, 30, 40, \text{ and } 55^\circ$.

Effects of yaw on elevon deflection limits have not yet been determined, but are thought to be relatively small. They will be included in future revisions of this document.

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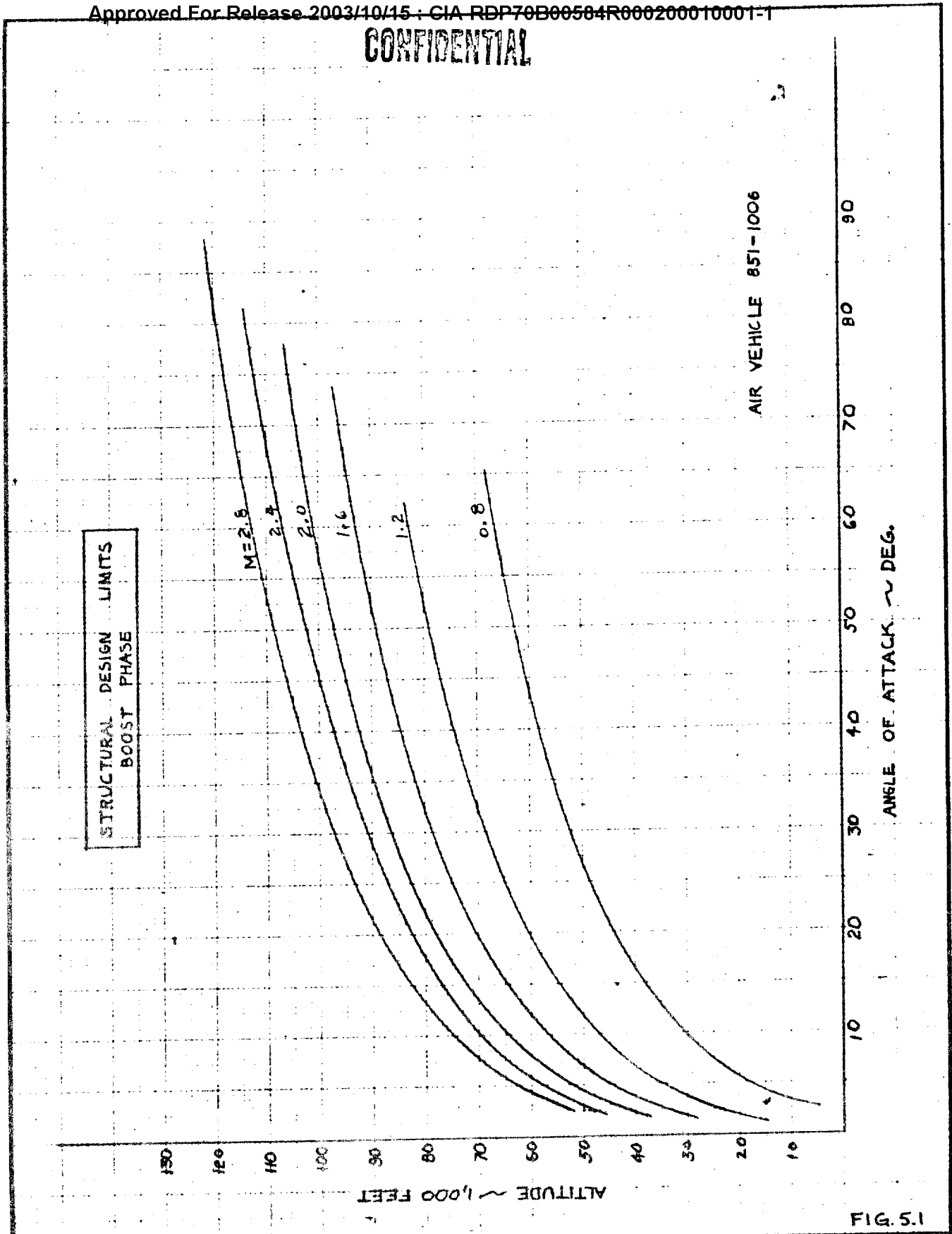


FIG. 5.1

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STRUCTURAL DESIGN LIMITS
BOOST PHASE

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2050D

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5.4

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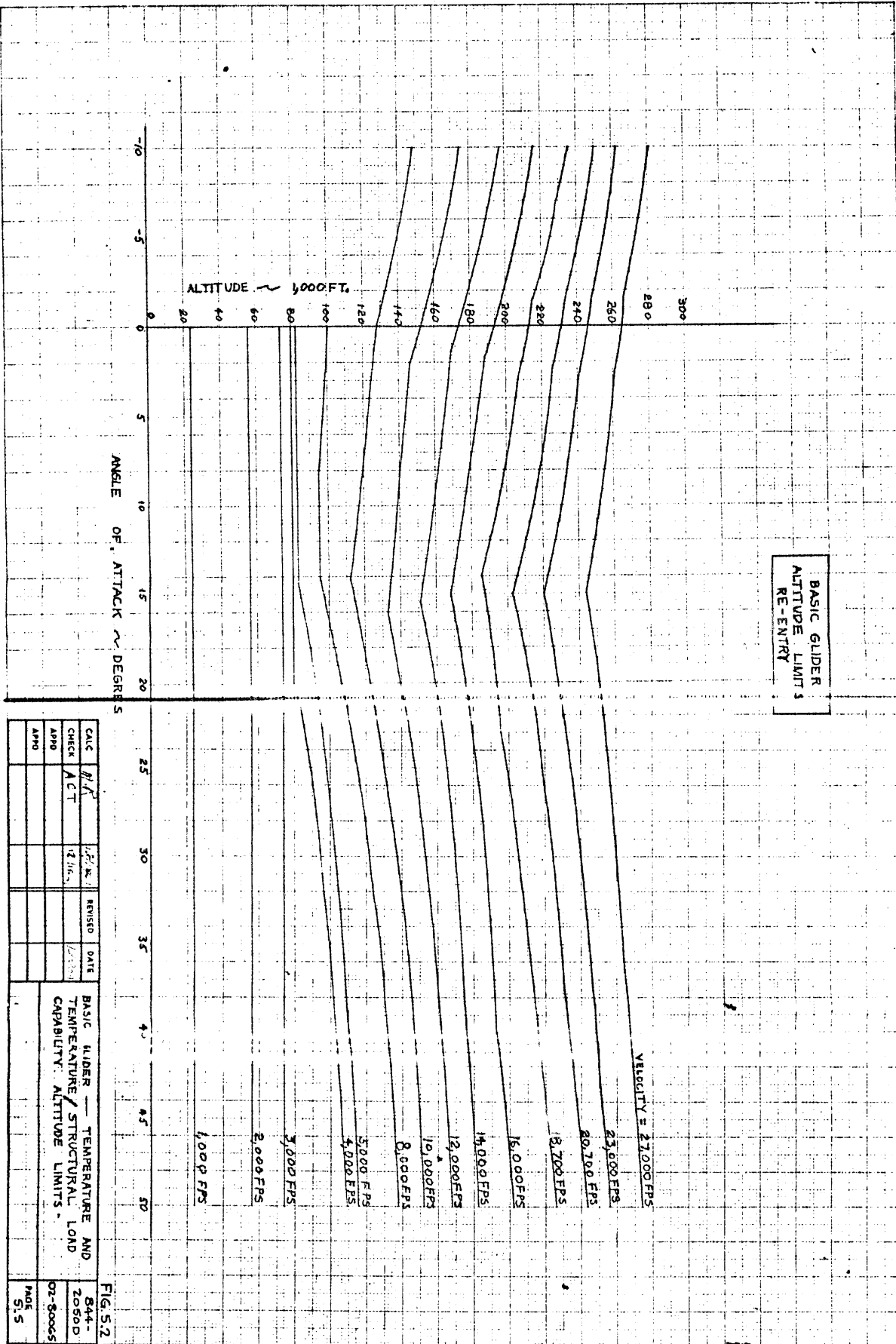
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BASIC GLIDER
ALTITUDE LIMITS
RE-ENTRY



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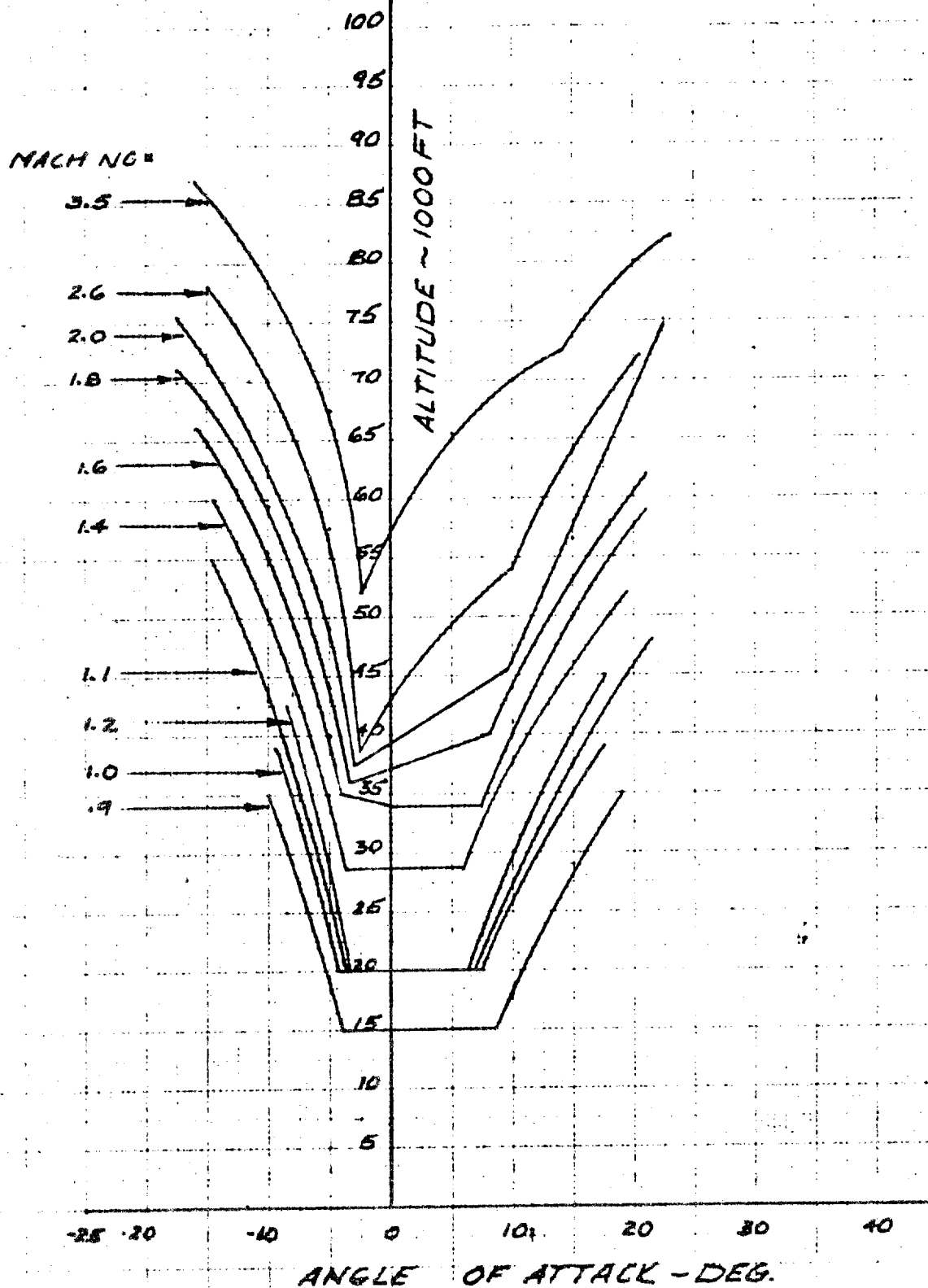


FIG. 5.3

CALC	DE. BENNETT	12-15-61	REVISED	DATE	STRUCTURAL LIMIT LINES-GLIDER PLUS TRANSITION SECTION- ABORT CONDITION	844- 2050 D
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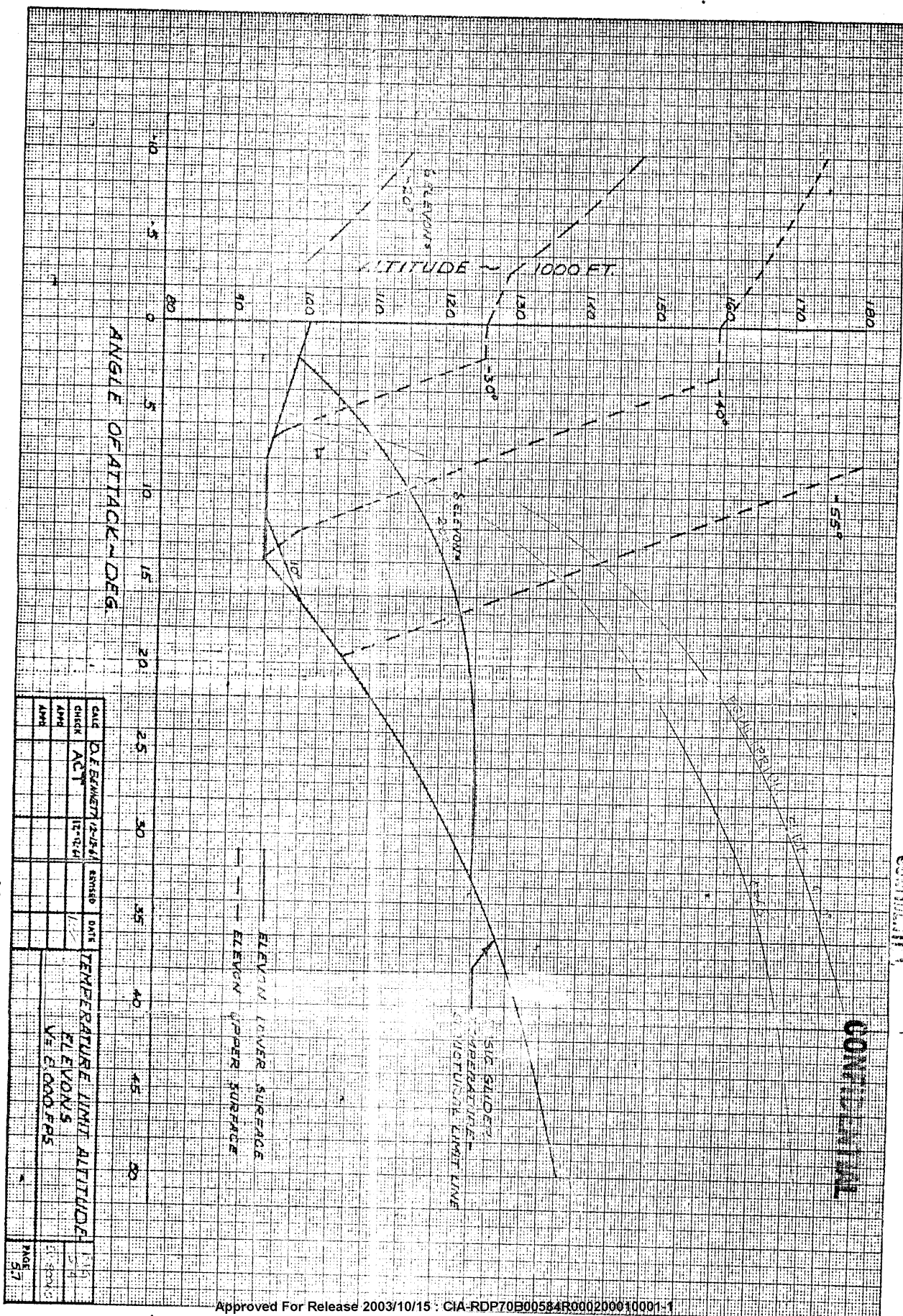
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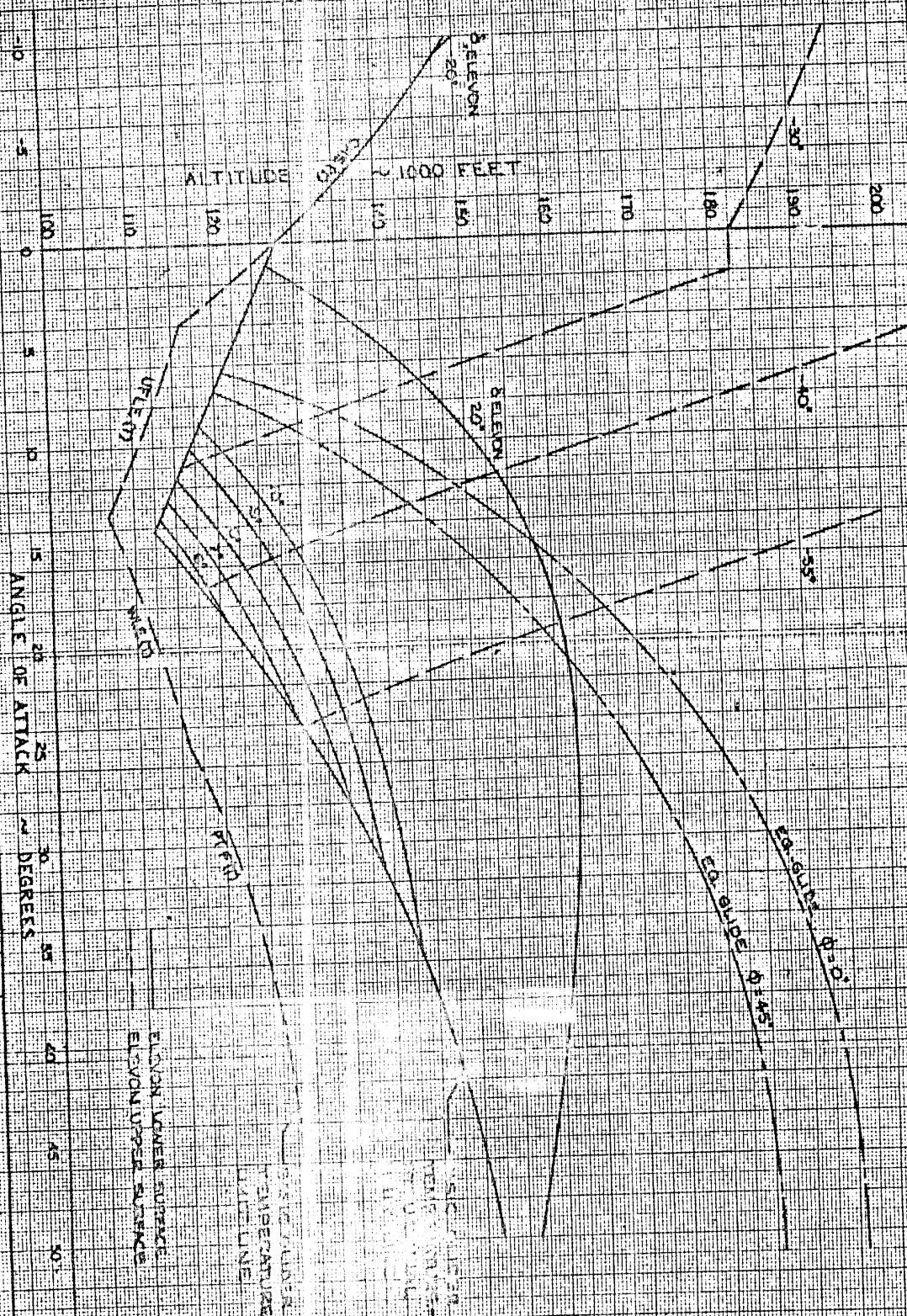
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UPDATES

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China
Communist
Party



CALL	DNR	WLT-CL	SERIAL	DATE	TEMPERATURE	LIMIT ALTITUDES
CHUCK	AET		WILLY		ELEVONS 3	V=10000 FPS
JACK						
JOHN						

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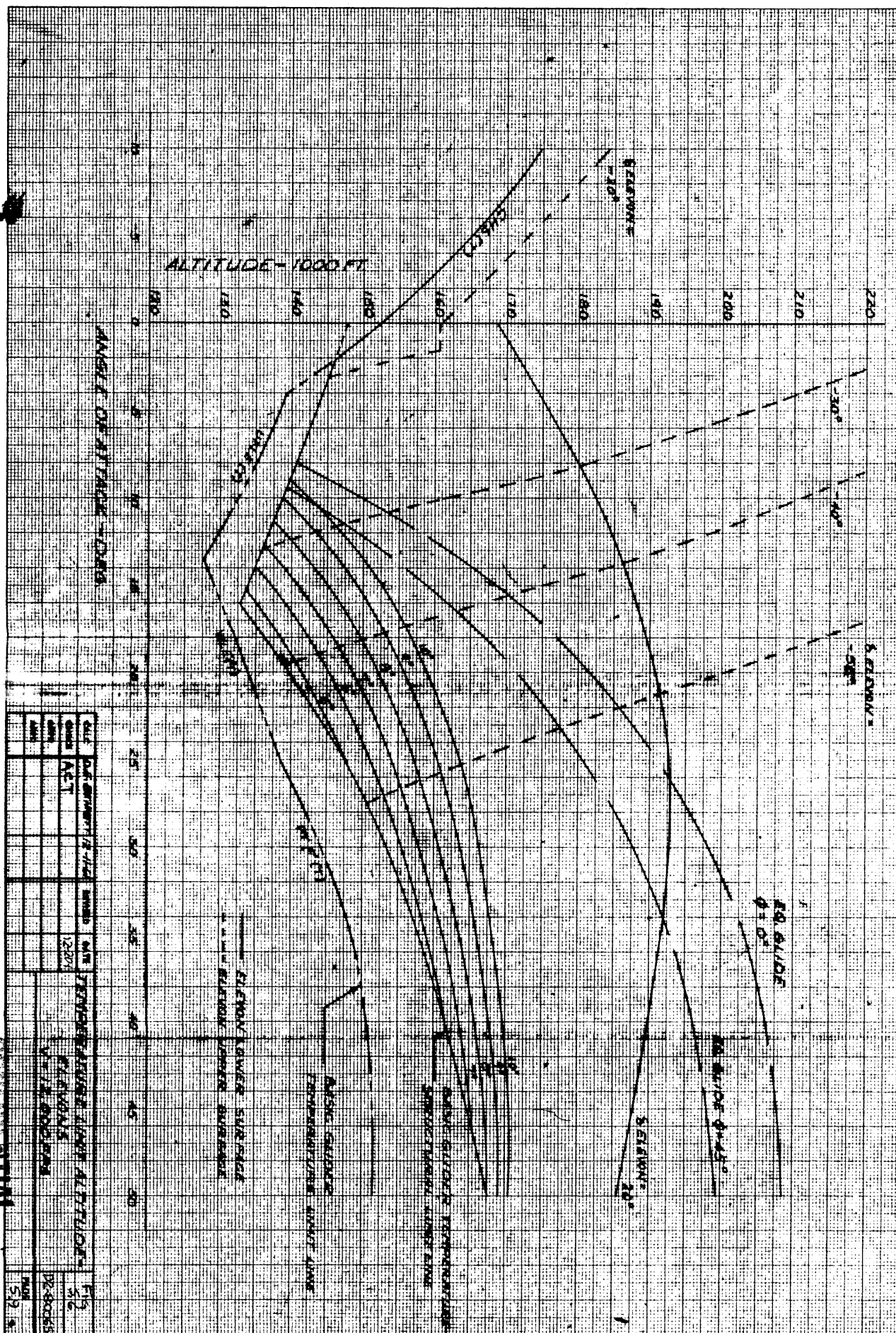
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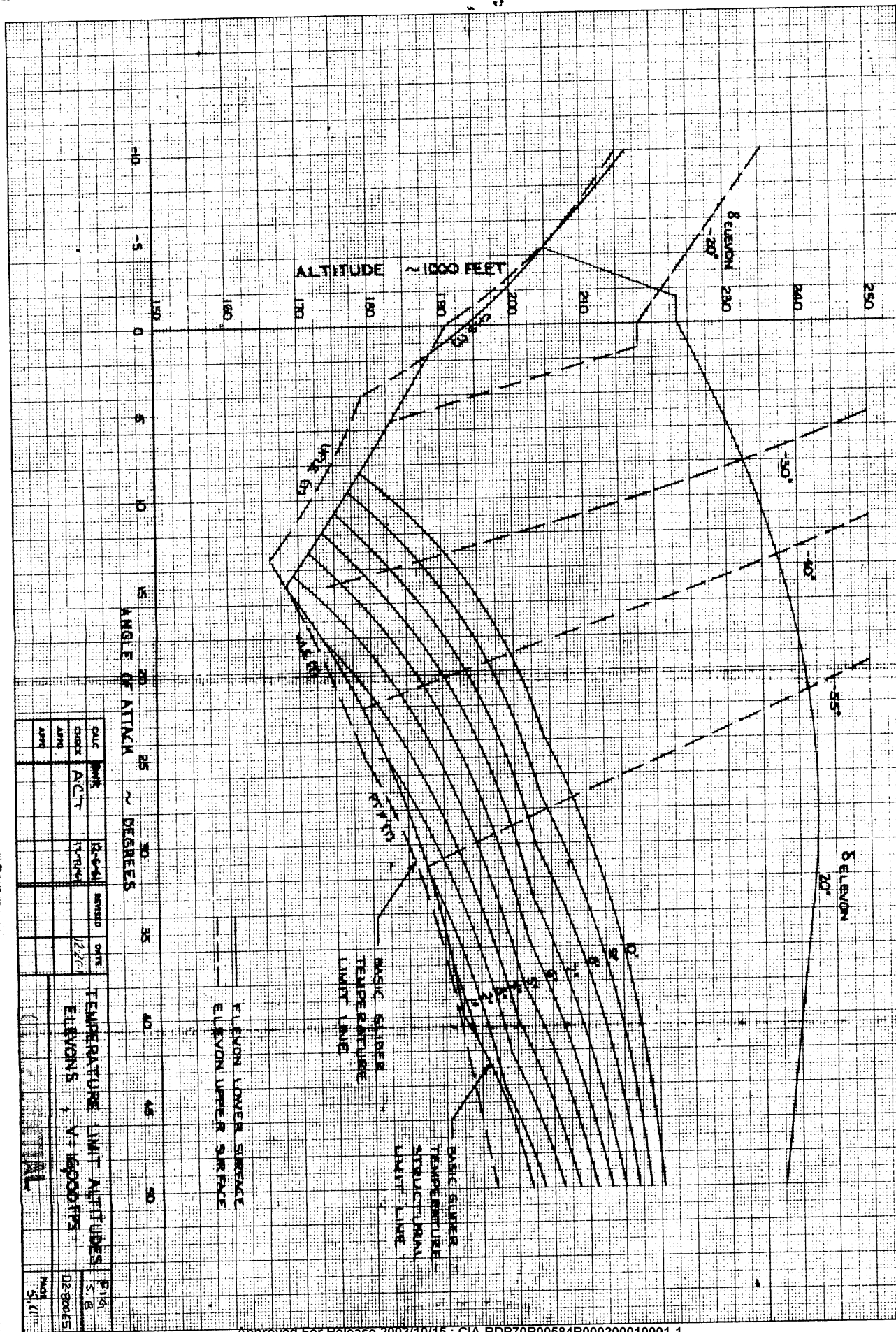
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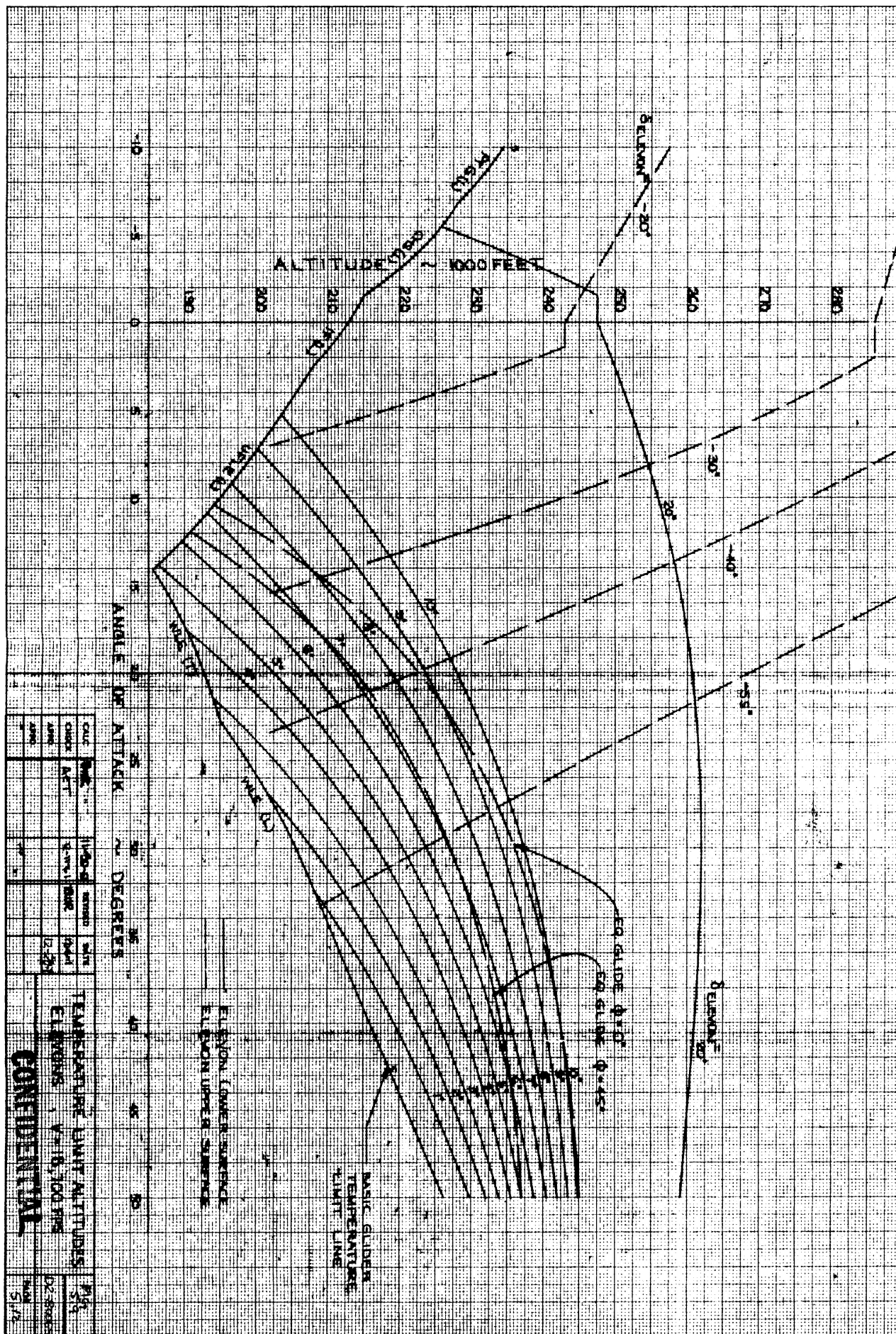


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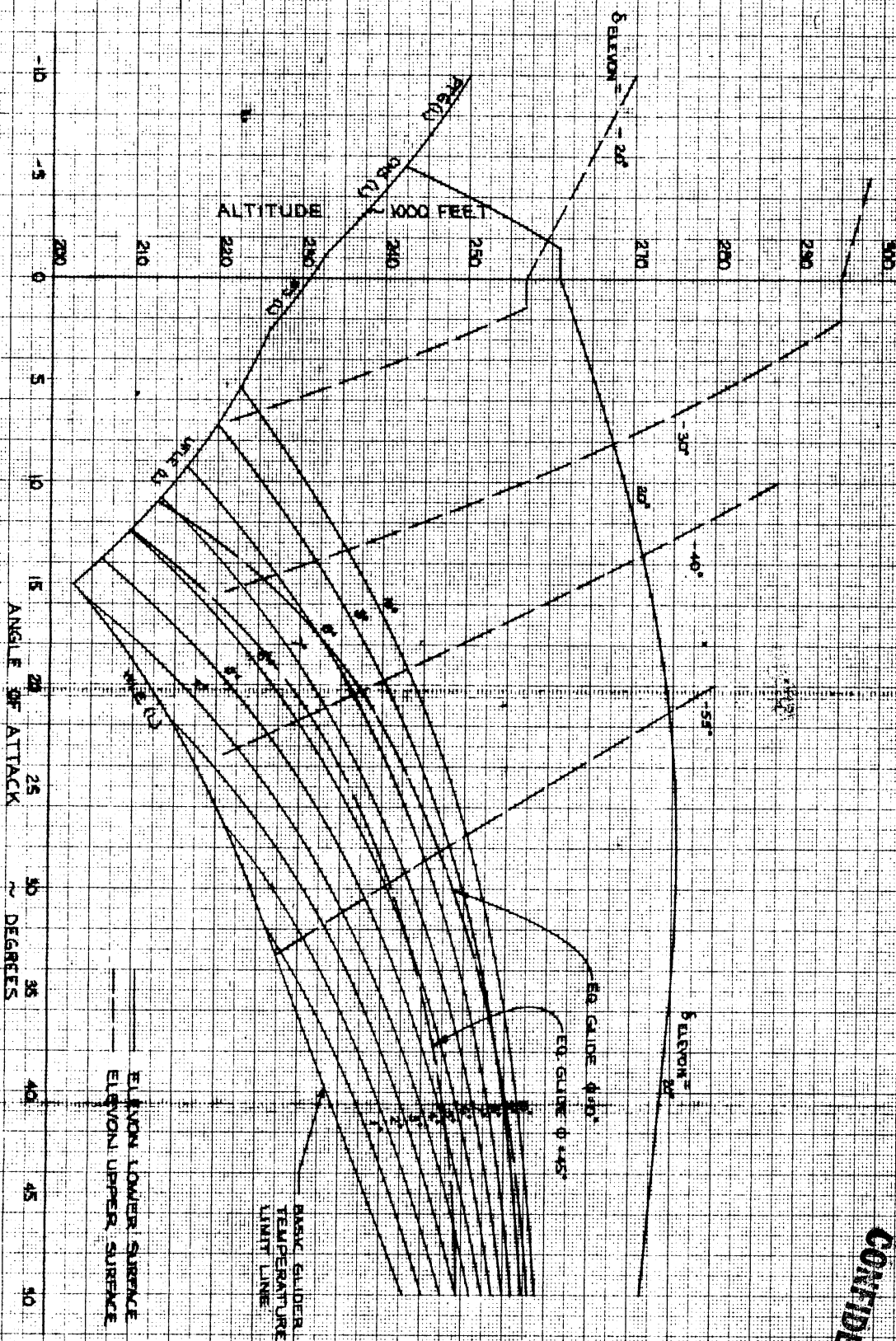
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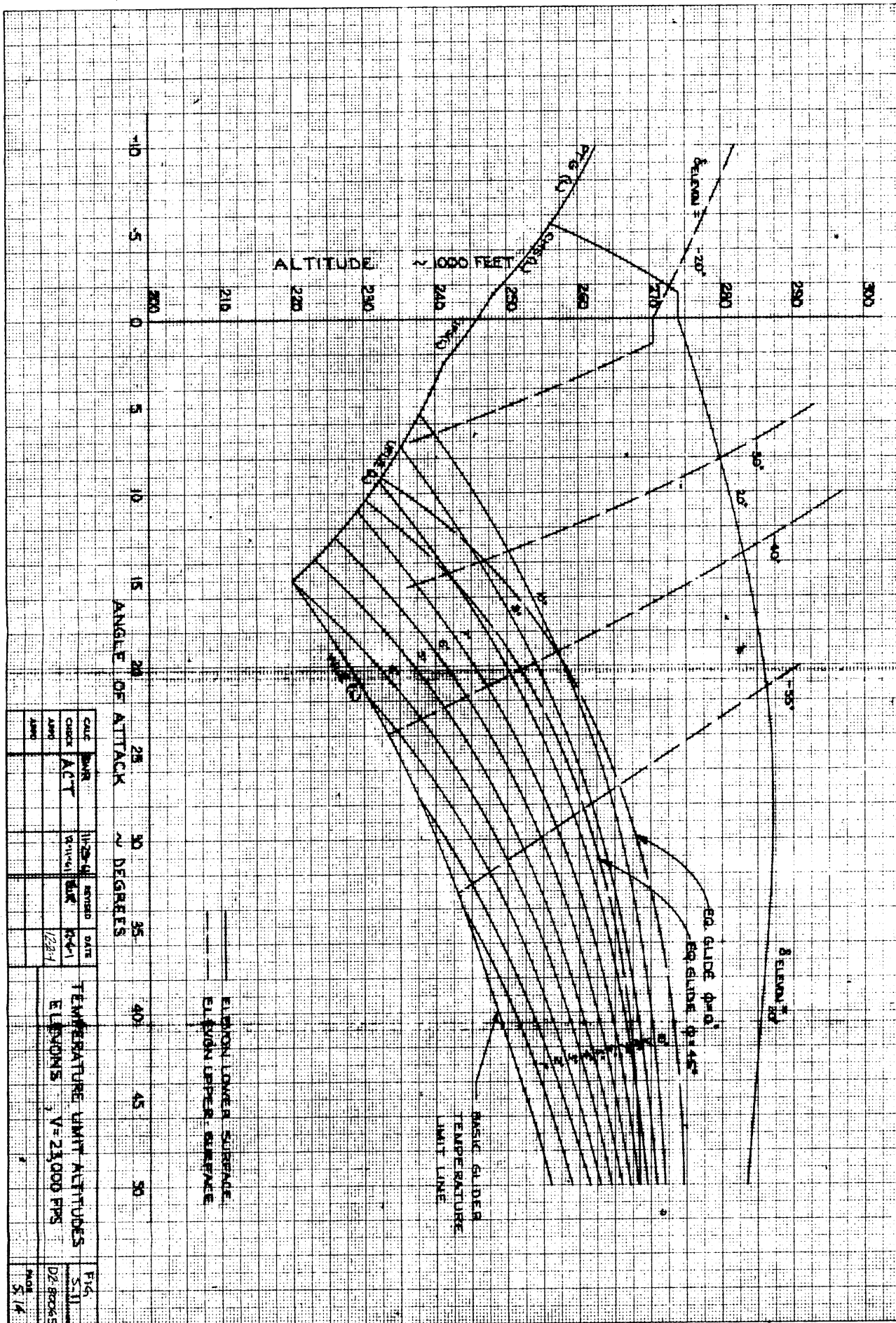
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CALC	DATE	REVISED	DATE	TEMPERATURE LIMIT ALTITUDES
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TEMPERATURE LIMIT ALTITUDES				5,10
ELEVONS, V = 20, 100 FPS				02-0005
MOD				5/13

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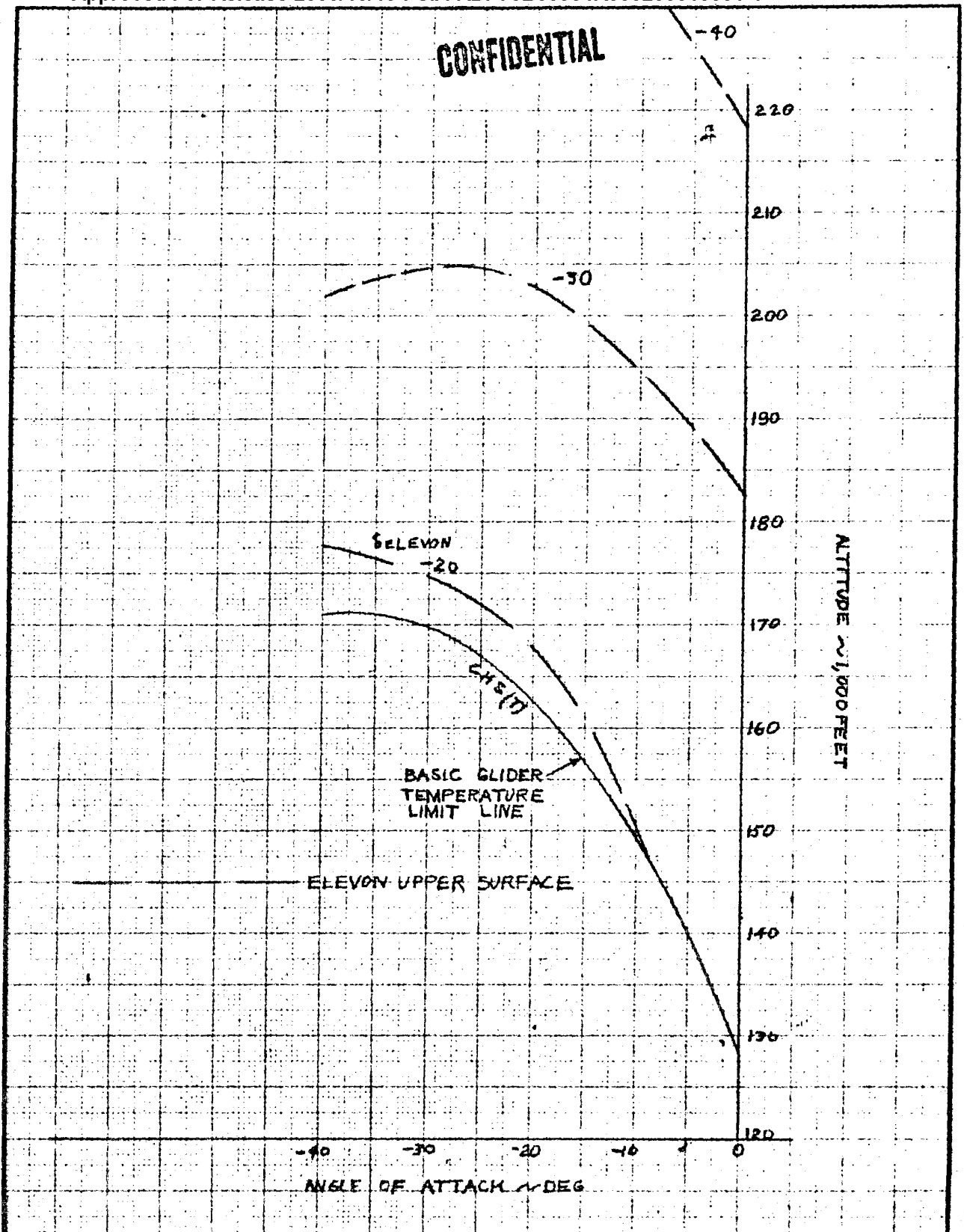


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ATTACK ON DECENTIES

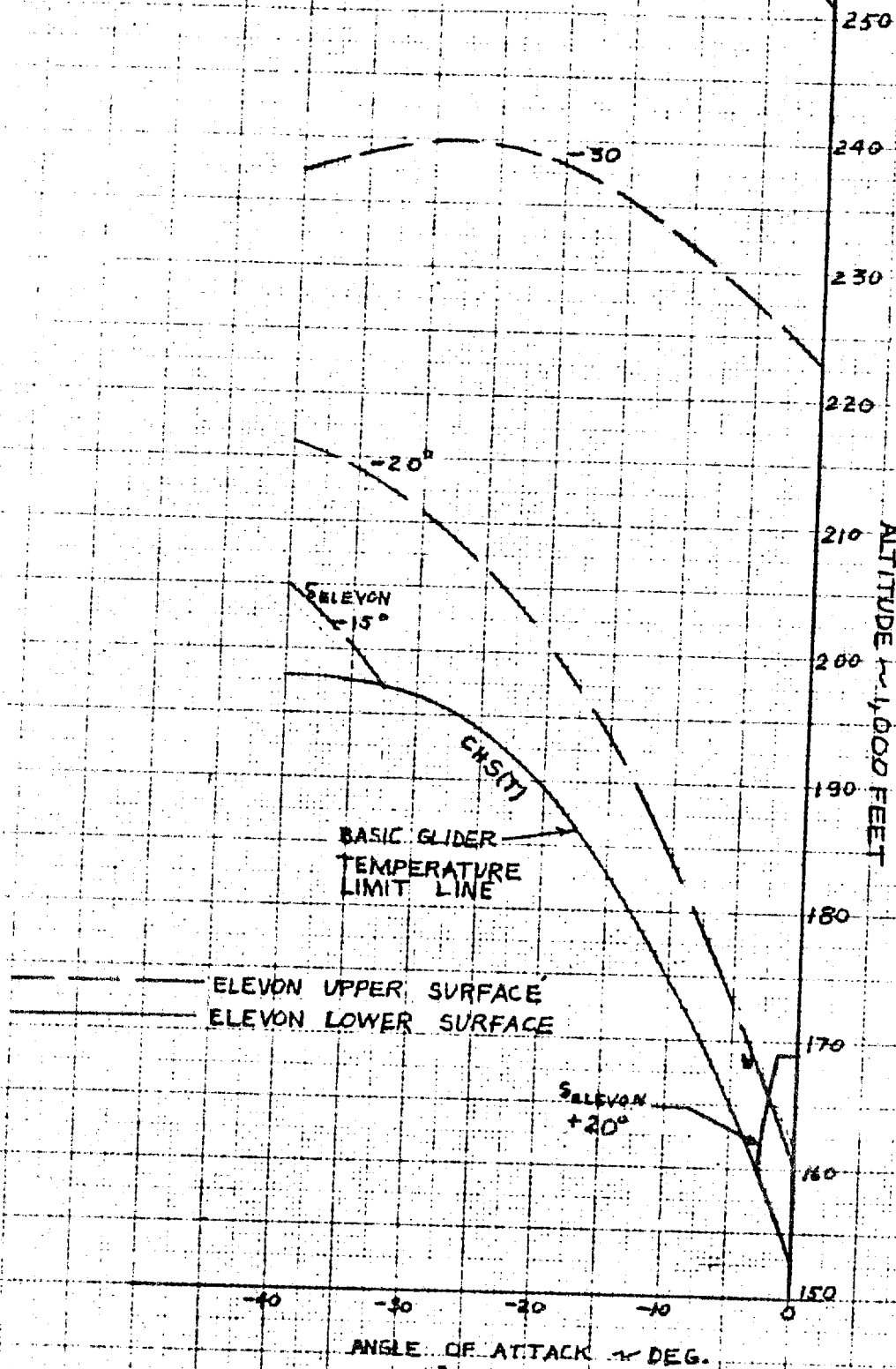
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CALC	MB ²	12/13/64	REVISED	DATE	TEMPERATURE LIMIT ALTITUDES ELEVONS , V=10,000 FPS	FIG 5.13
CHECK	DSM	12-3-64	12-3-64			D2-80065
APR					THE BOEING COMPANY	PAGE 5.16
APR						

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TEMPERATURE LIMIT ALTITUDE
ELEVONS , V=12,000FPS

FIG
5.14

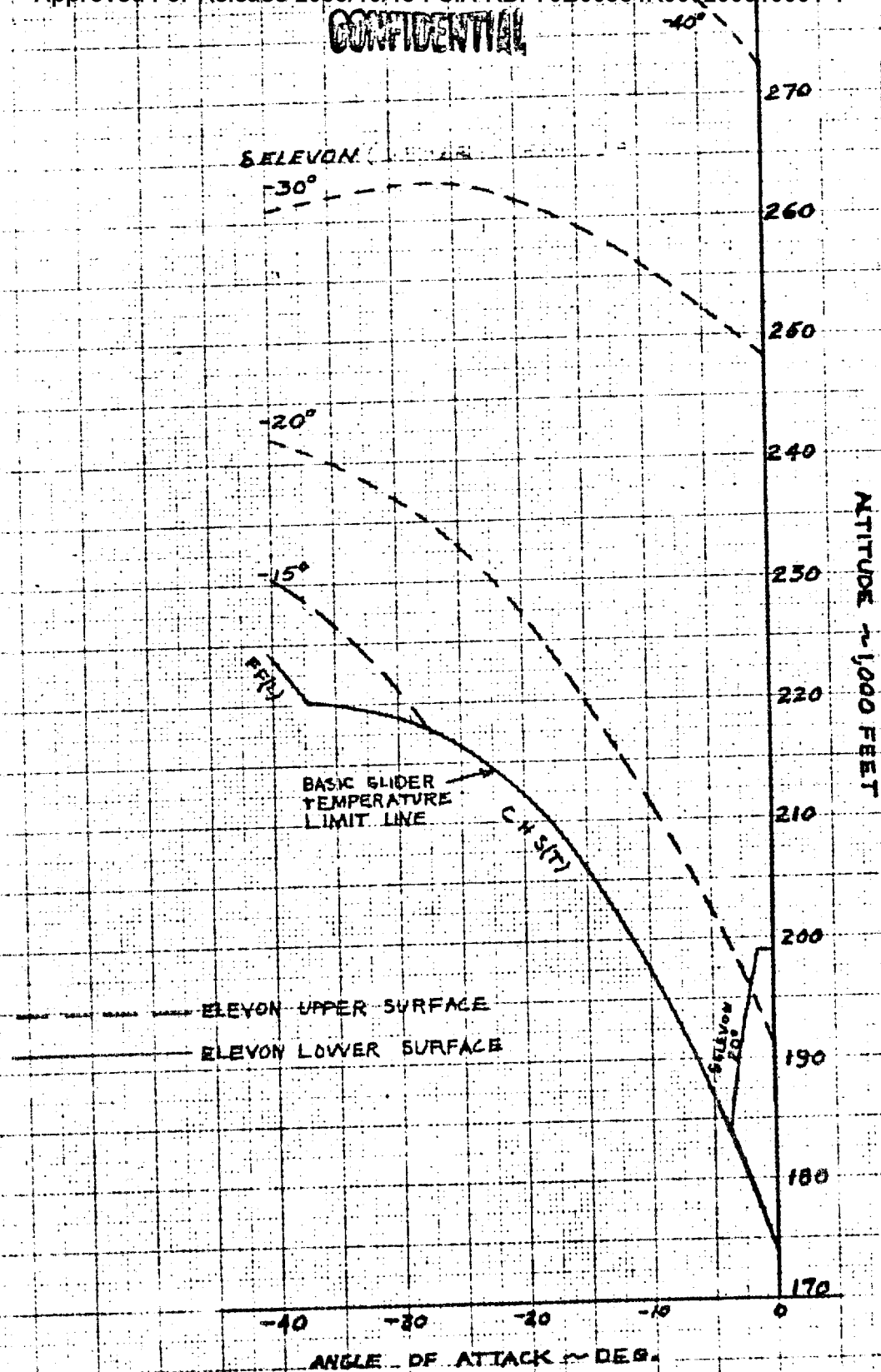
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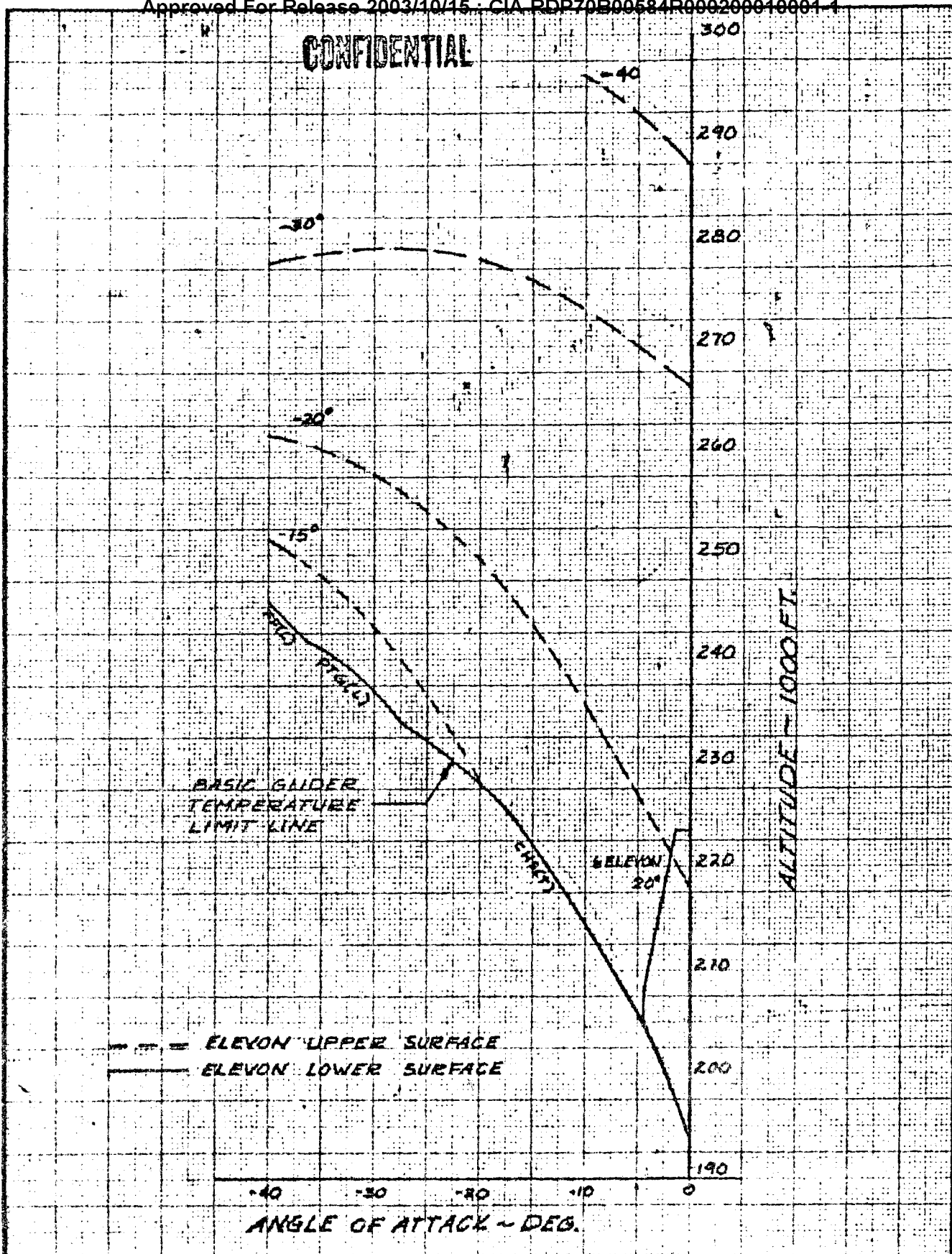
TEMPERATURE LIMIT ALTITUDE
ELEVONS V=14,000 FPS

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Fig
5.15
D2-80065
PAGE
5.18

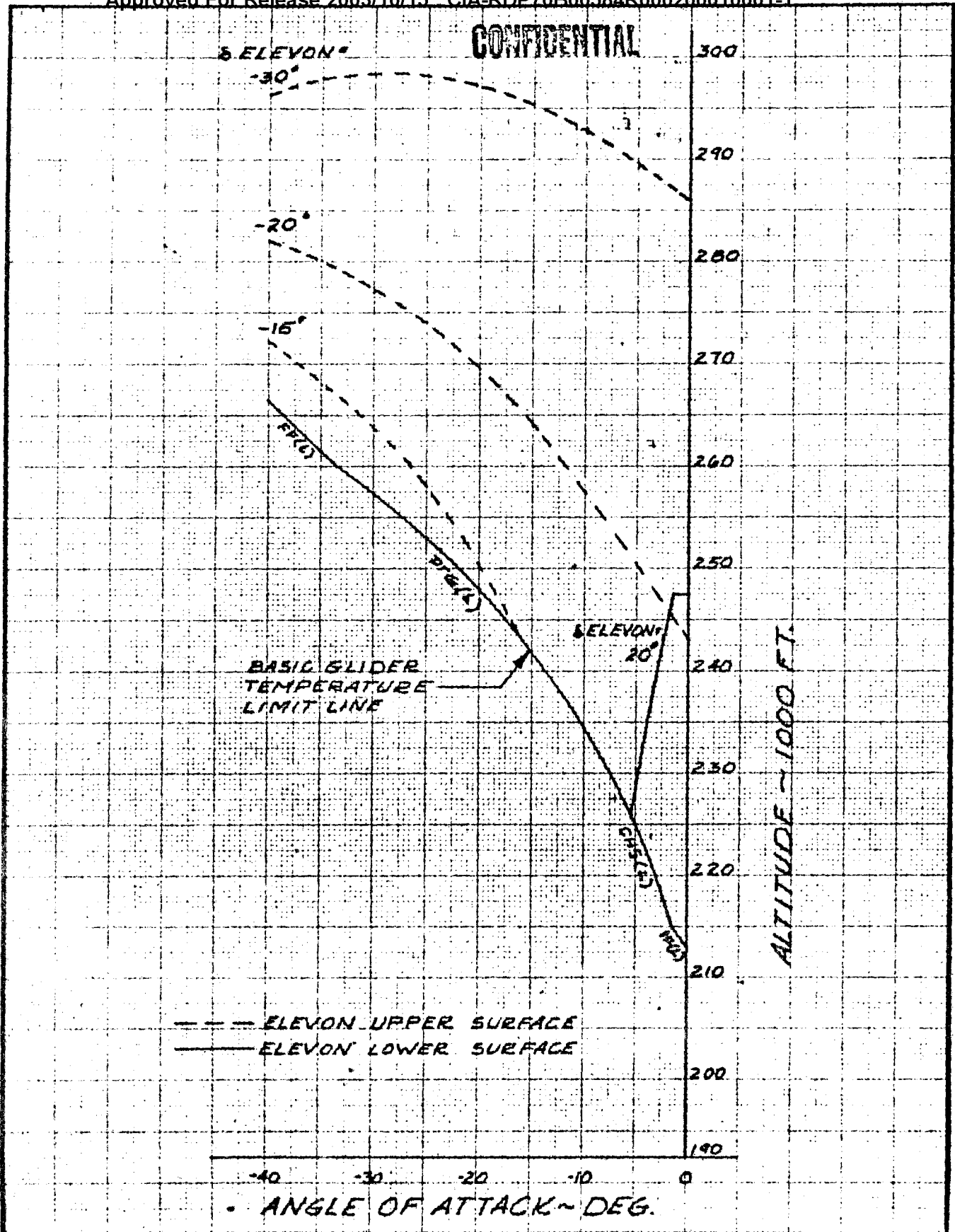
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CALC	D.E. BENNETT	12-12-61	REVISED	DATE	TEMPERATURE LIMIT ALTITUDE ELEVONS - V=16,000 FPS THE BOEING COMPANY	FIG S.16
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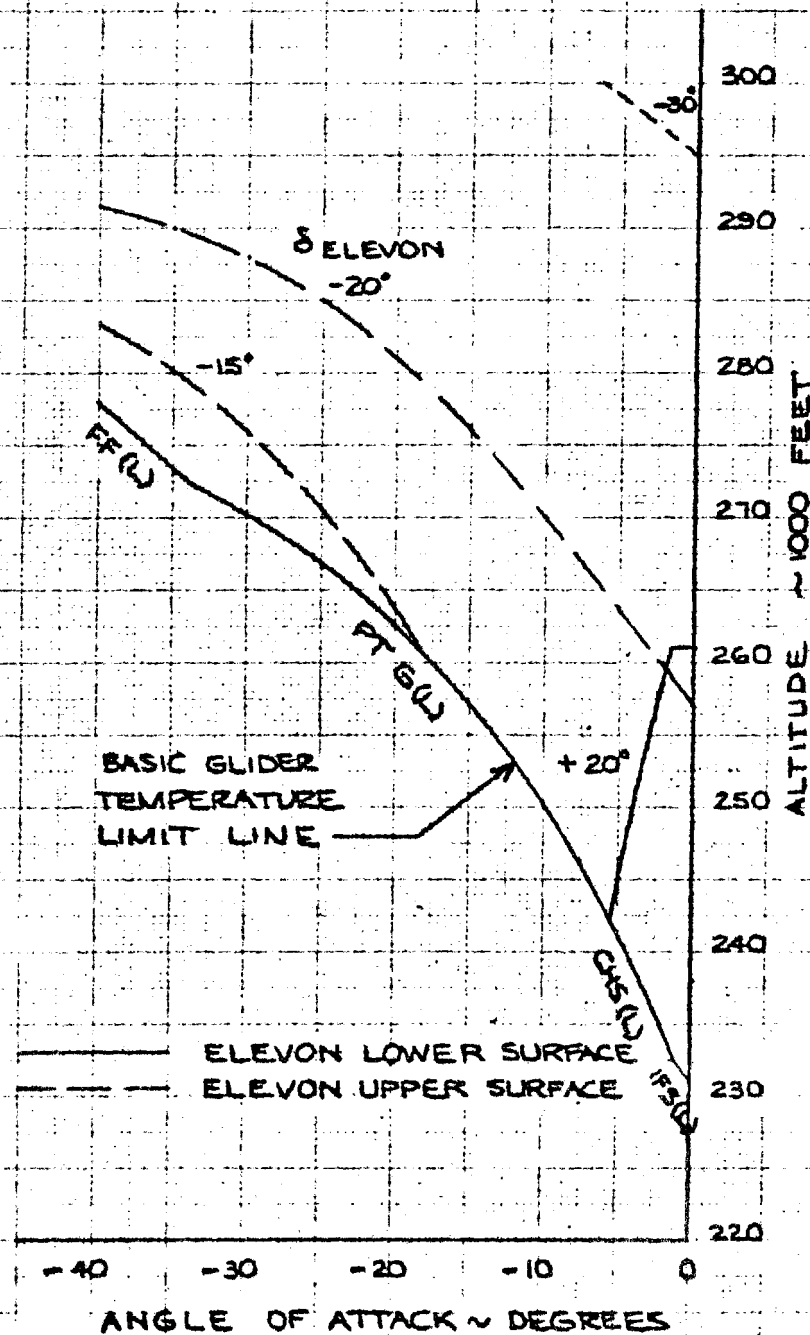
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CALC	D.E. BENNETT	12-13-61	REVISED	DATE	TEMPERATURE LIMIT ALTITUDE ELEVONS - V=18,700 FPS	FIG 5.17
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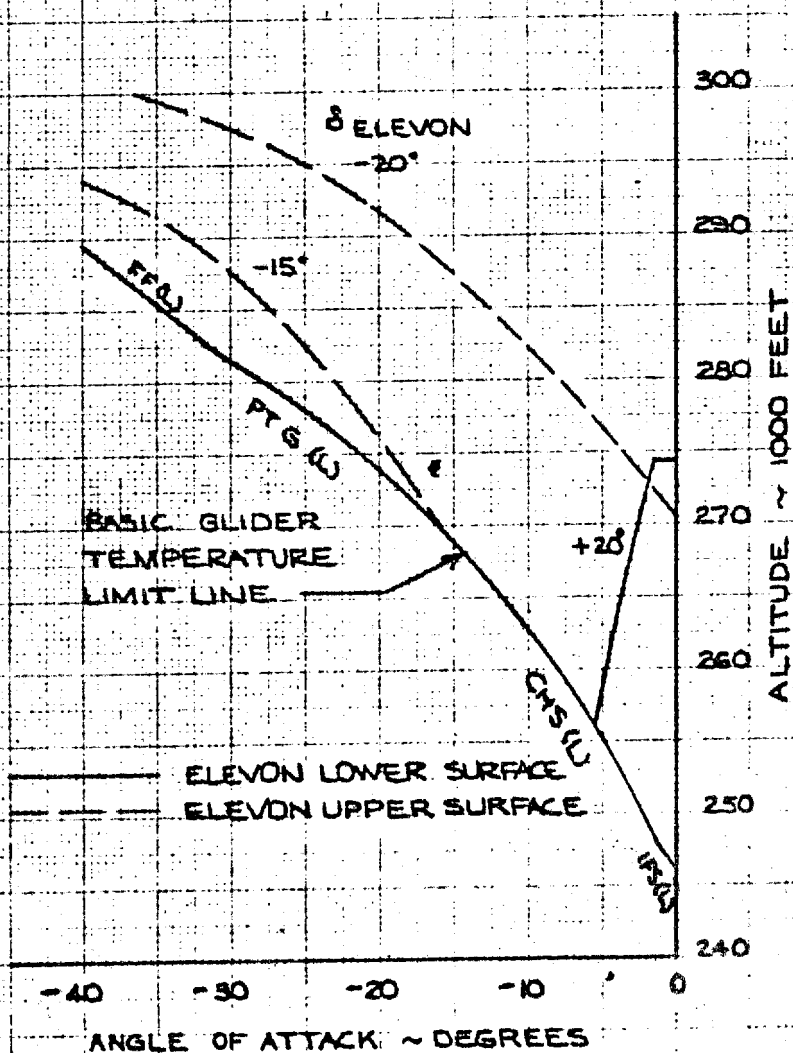


CALC	BWR	12-13-61	REVISED	DATE	TEMPERATURE LIMIT ALTITUDE LEVONS, V=20,700	FIG S.18
CHECK	A.T	12-13-61				D2-80065
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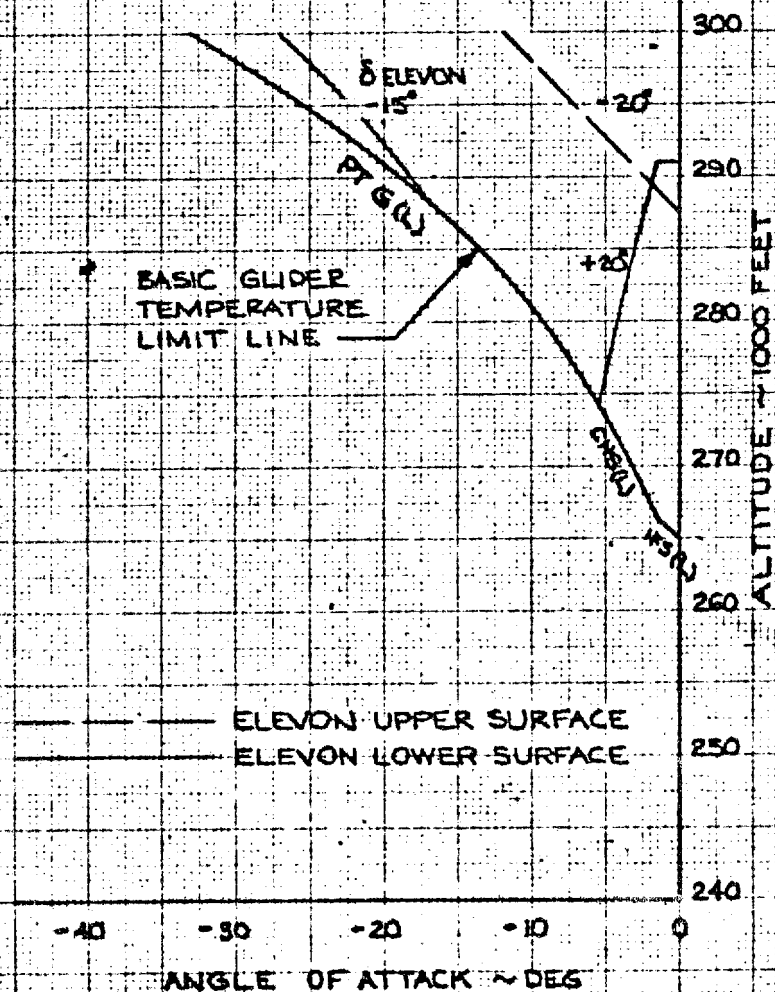
TEMPERATURE LIMIT ALTITUDE
ELEVONS , V = 23000 FPS

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FIG
5.19
D2-80065
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TEMPERATURE LIMIT ALTITUDES
ELEVONS, $V = 27000$ FPS

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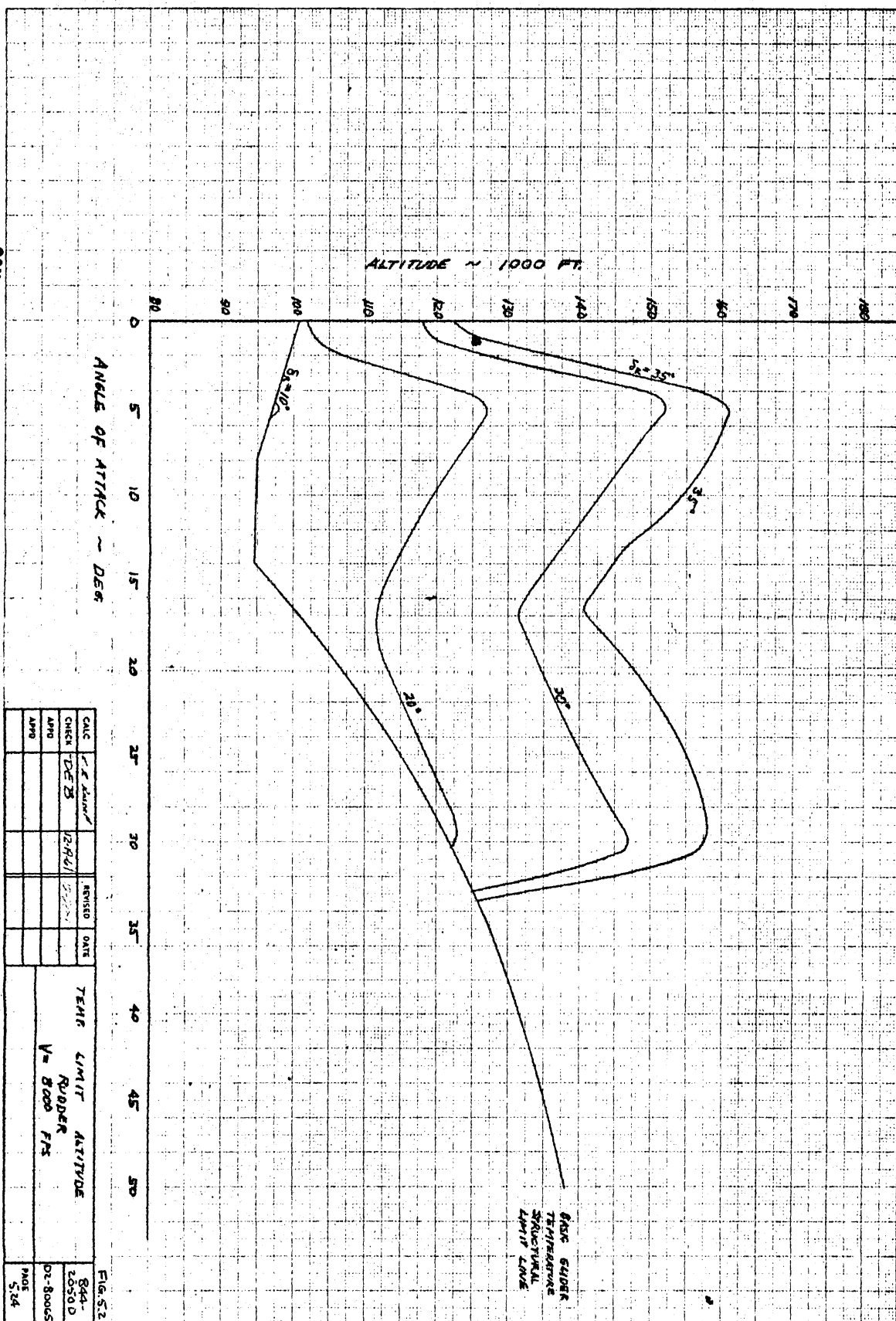
FIG
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TEMPERATURE LIMIT ALTITUDES				844- 2050D
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RUDER 10/12,000 FPS				02-804-5
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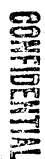
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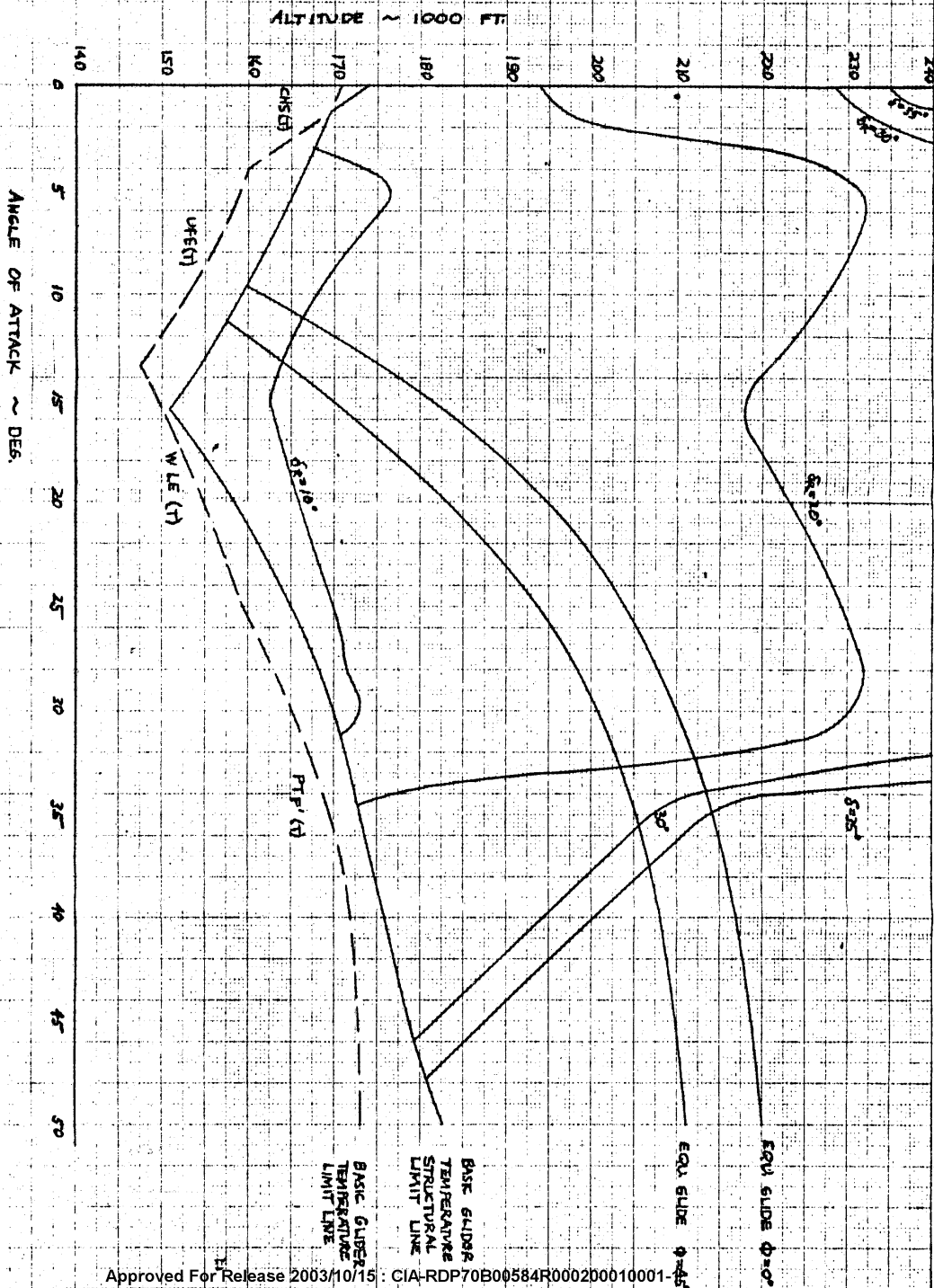


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TEMPERATURE LIMIT ALTITUDES

RUDER

V₀ 14,000 FPS

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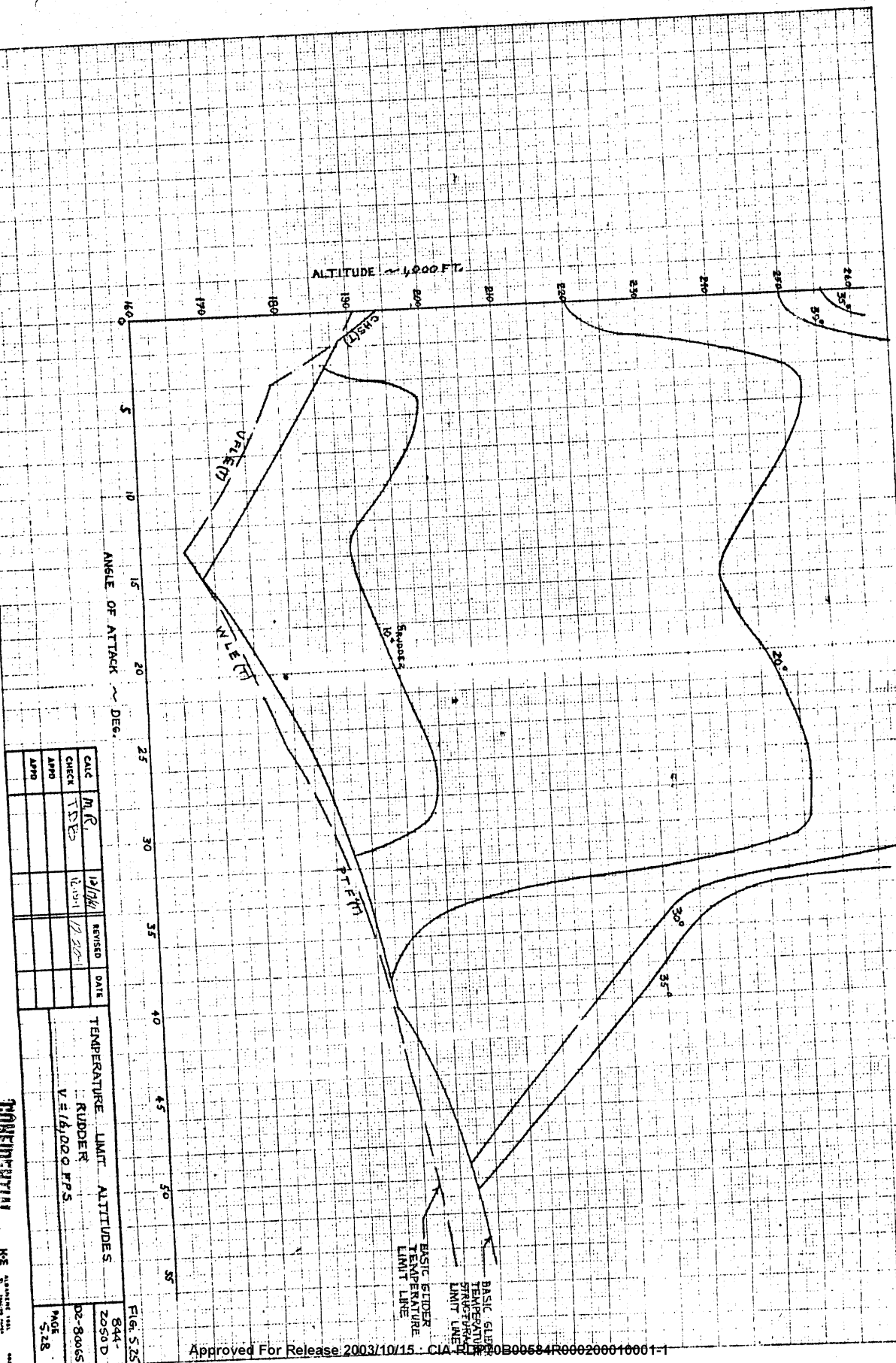
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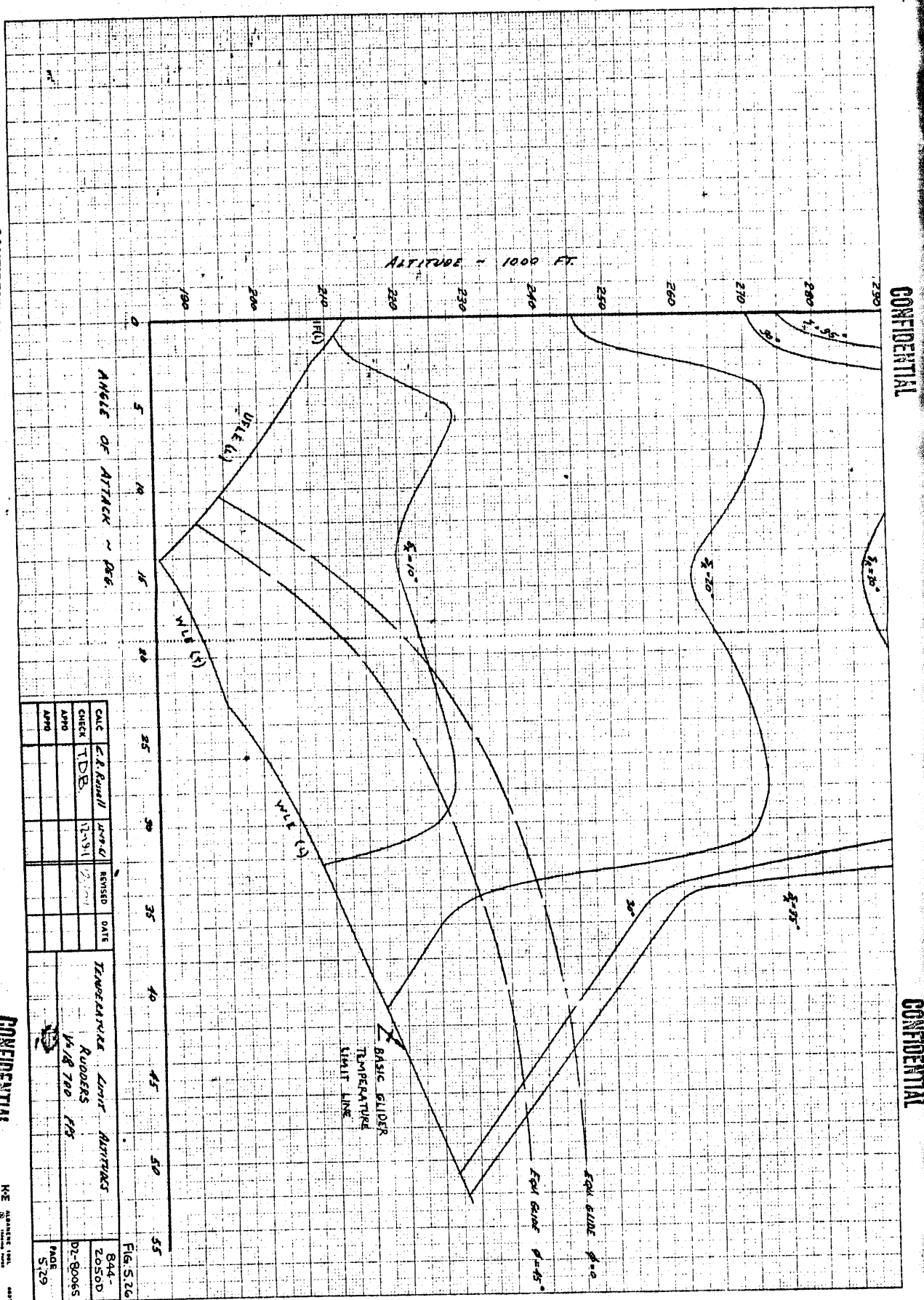


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ALDAMINE TOOL
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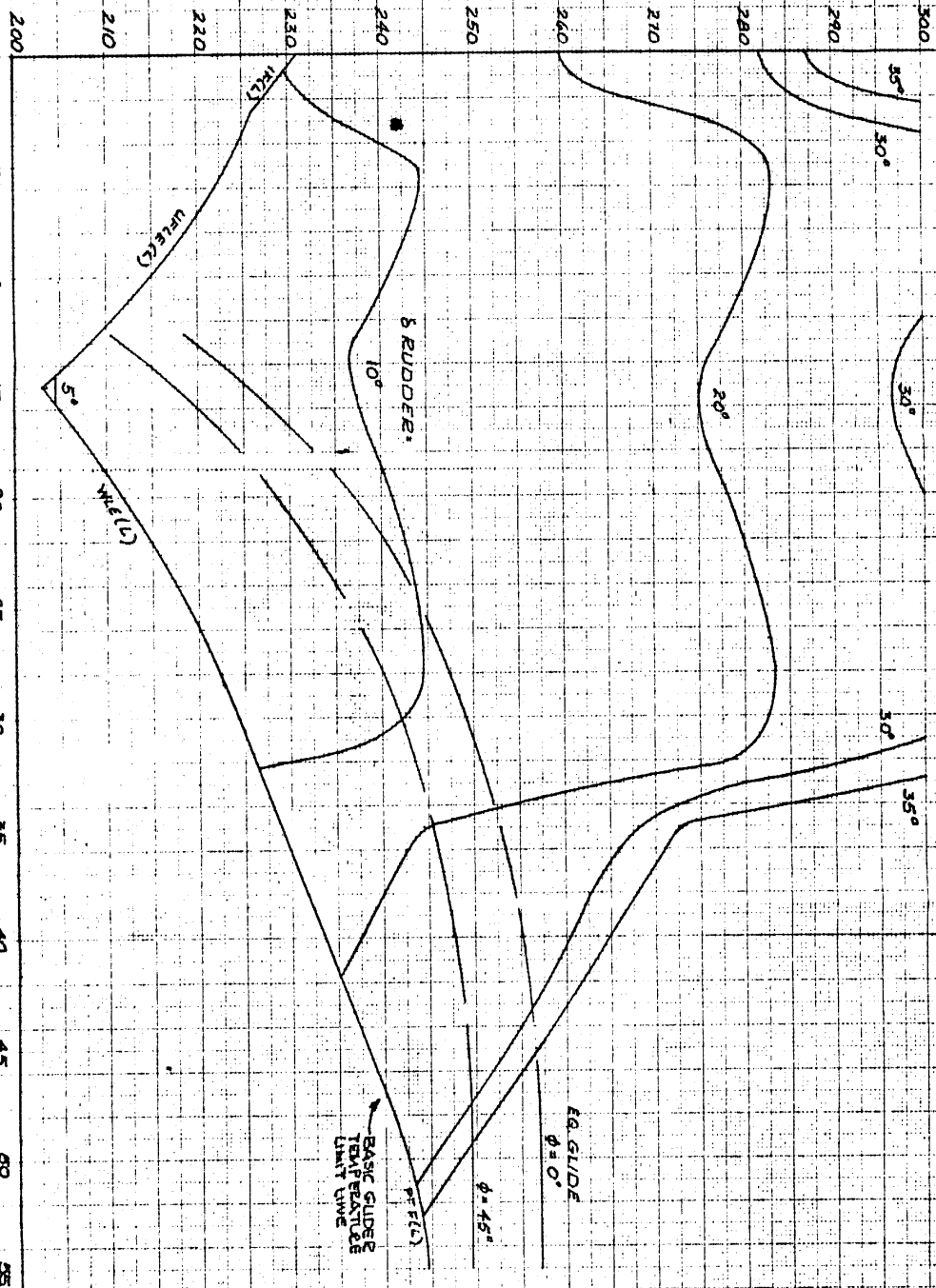


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ANGLE OF ATTACK - DEG.



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CHECK	T.D.B.	12-1-61		
APPRO				RUDDERS V-20,700FPS
APPRO				
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FIG. 5.27

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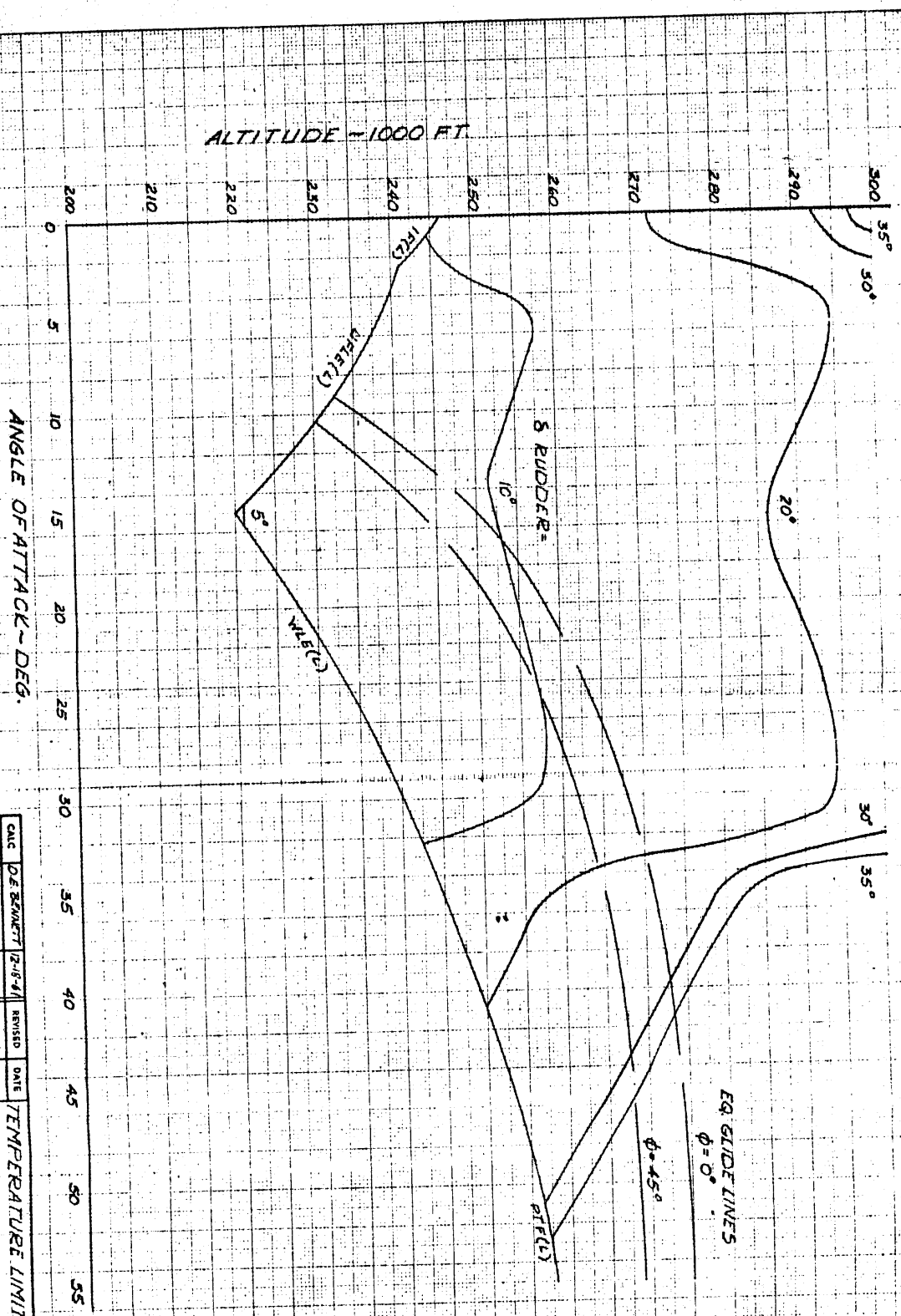
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FIG. 5.28
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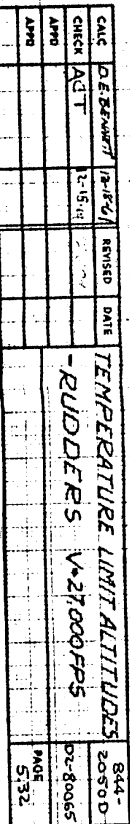
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CALC	DE SIGNET	7-18-41	REVISED	DATE	TEMPERATURE LIMIT ALTITUDES
CHECK	ACT	W/2/11	11/1		RUDDERS V=23000FPS
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FIG. 5.28

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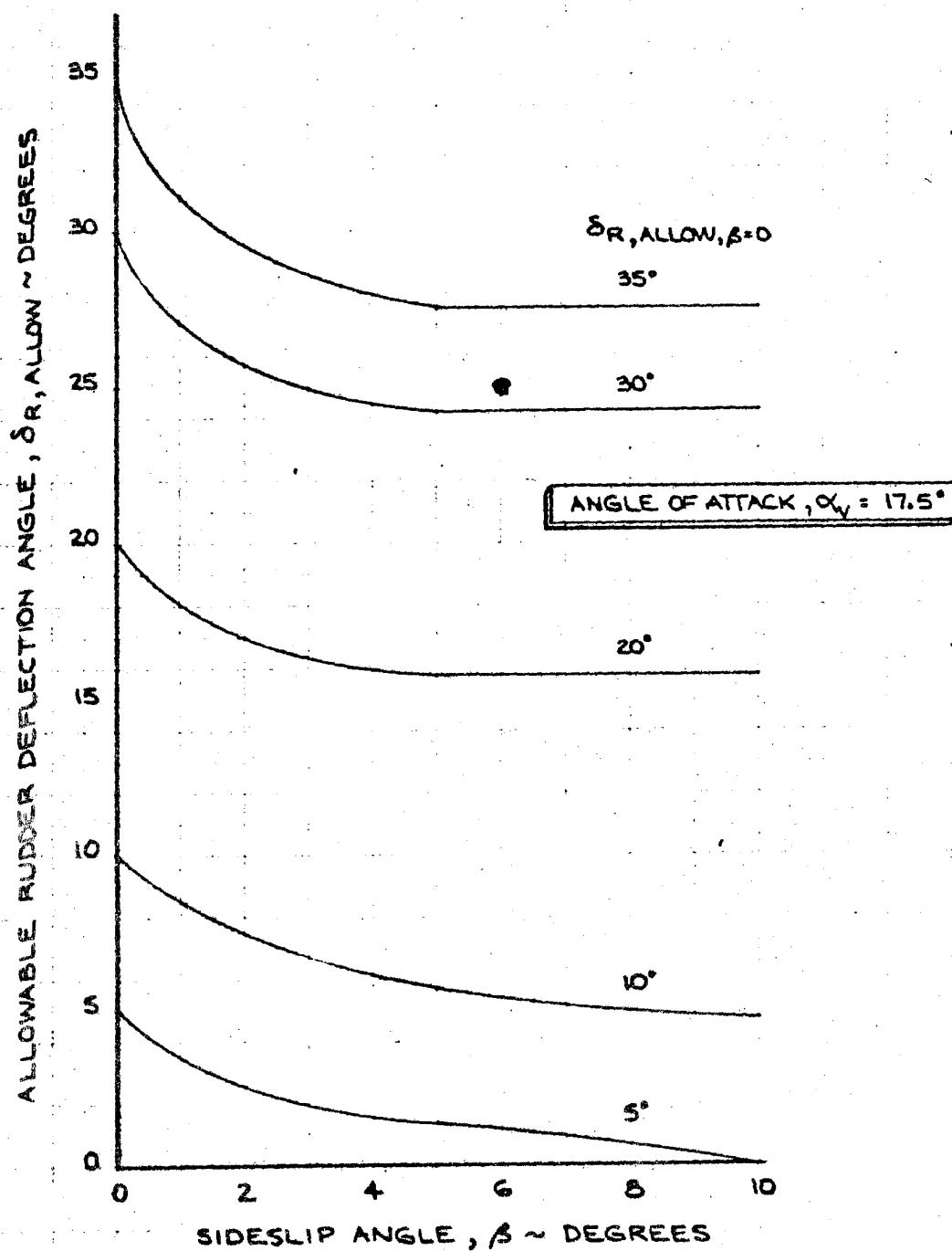
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FIG. 5.30

CALC	TDB/BNR	12-13-61	REVISED	DATE	MAXIMUM ALLOWABLE RUDDER DEFLECTION	844- 2050D
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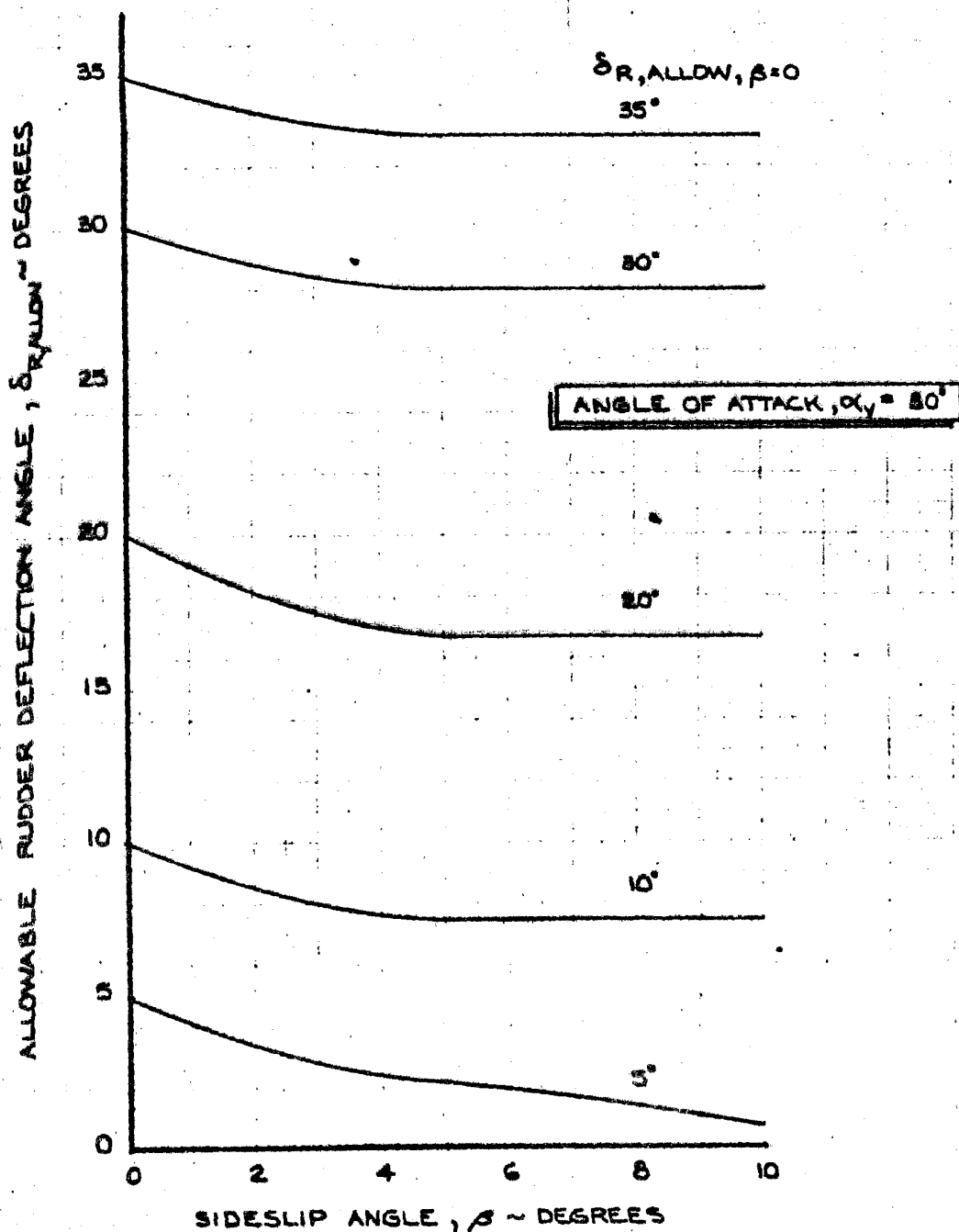


FIG. 5.31

CALC	TDB/BNR	12-19-61	REVISED	DATE
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MAXIMUM ALLOWABLE
RUDDER DEFLECTION

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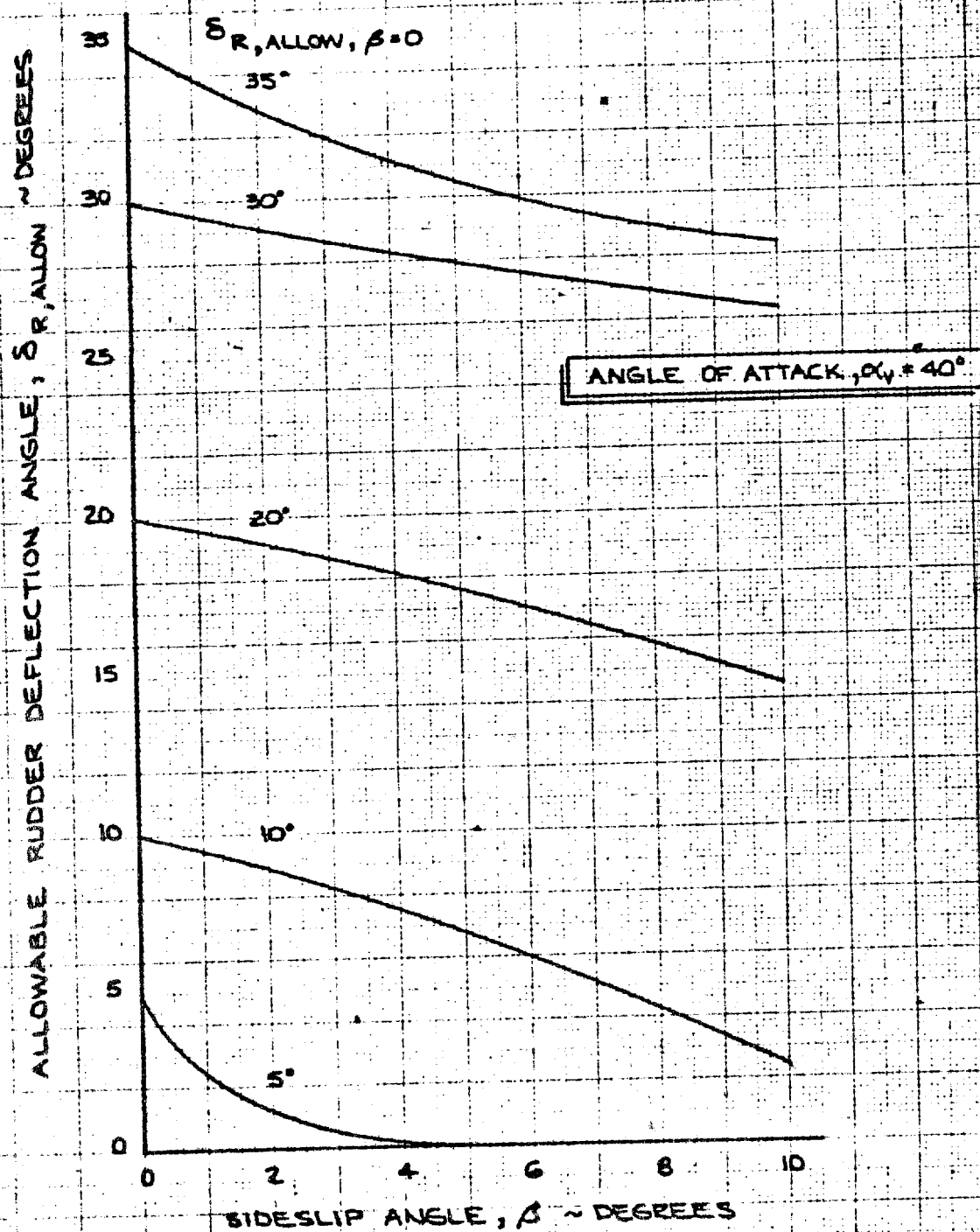


FIG. 5.32

CALC	TDB/BWR	12-19-61	REVISED	DATE
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MAXIMUM ALLOWABLE
RUDDER DEFLECTION

THE BOEING COMPANY

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20500
DZ-80065
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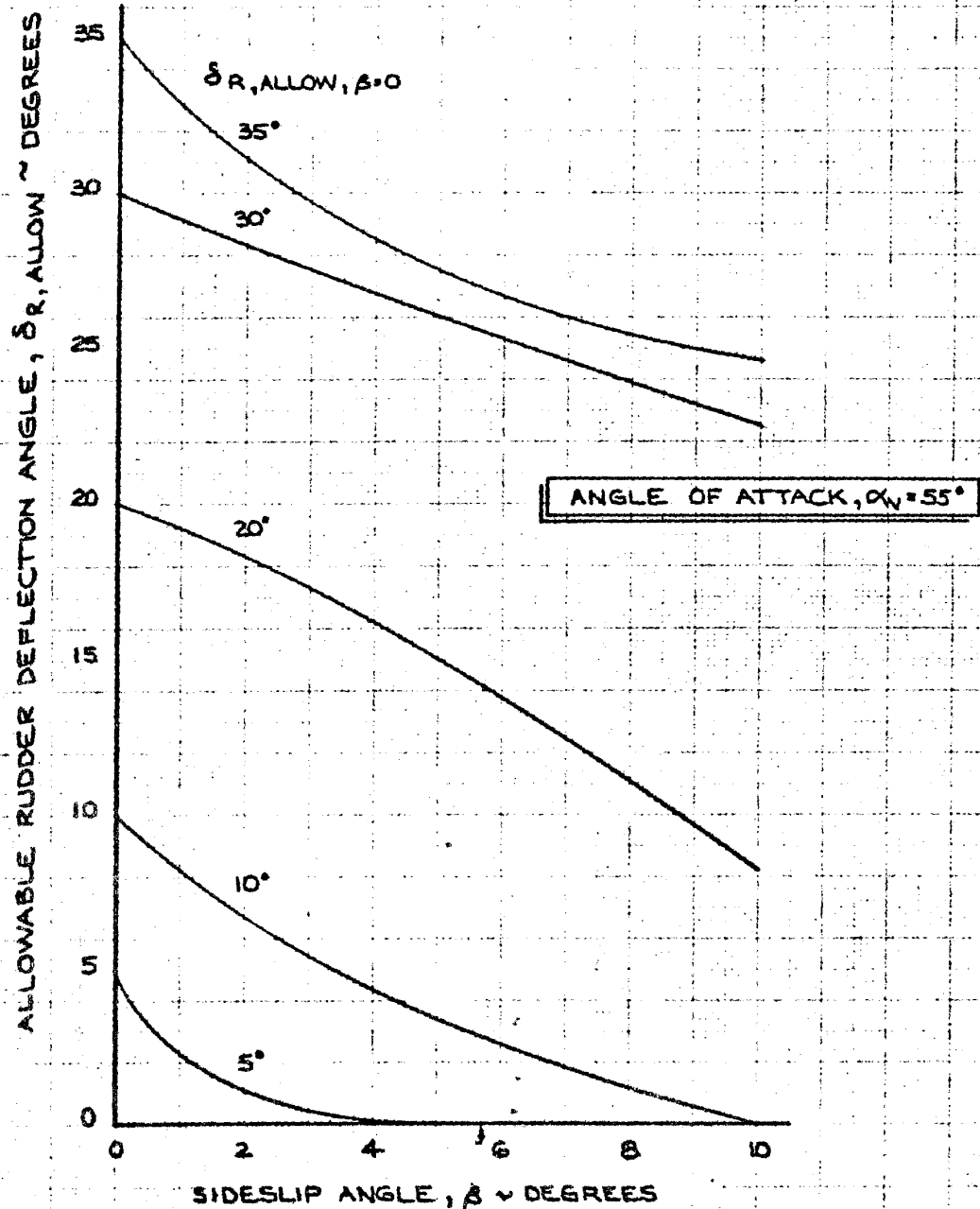


FIG. 5.33

CALC	TDB/BWR	12-18-61	REVISED	DATE	MAXIMUM ALLOWABLE RUDDER DEFLECTION	844- 20500
CHECK	11 E	12-22-61				02-80065
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APR						5.36
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6.0

GLIDER STATIC STABILITY AND CONTROL

The static stability and control aerodynamic characteristics and surface hinge moment characteristics for the Dyna Soar glider, model 844-2050 revision D are presented in the following sub sections. The data from Mach number of 22 and 250,000 feet altitude through low speed landing are based on wind tunnel data. Modifications to these data were required to account for configuration changes that occurred on the last revision to the glider configuration.

Most of the data presented are for the rigid glider. Effects of thermal deformation on longitudinal stability and control are presented at hypersonic speeds. Only limited data on the aeroelastic glider are presented. These data are shown in Section 8. In general, the effects of thermal deformation and aeroelasticity are small. Additional work is currently in progress to better define these characteristics. These data will be presented in future revisions to this document.

Some limited data are also presented on longitudinal stability and control at extreme altitudes at near orbital velocity. Data are presented at altitudes to 500,000 feet where free molecular flow was assumed. These data are based on the limited theory available and maybe subject to significant errors, particularly at the intermediate altitudes around 350,000 feet.

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6.1 LONGITUDINAL STABILITY AND CONTROL

Presented in this section are the static longitudinal stability parameters of the Dyna-Soar glider configuration 844-2050 D over the Mach range from landing speed to high hypersonic. Longitudinal stability and elevon effectiveness are defined by normal force and pitching moment coefficients presented at the nominal center of gravity location of 44% of the mean aerodynamic chord and water line 124.

At hypersonic speeds, the glider is subject to thermal deformation produced by the flight temperature environment. Data are presented for the resulting configuration and are identified as "hot shape".

All data presented in this section are representative of the rigid glider. Aeroelastic effects have been determined and are included in Section 8.0.

Longitudinal stability and elevon effectiveness over the Mach range are summarized in the following Figures; (6.1) trimmed aerodynamic center, (6.2) normal force curve slope, (6.3) pitching moment and angle of attack at zero normal force, (6.4) elevon required to trim, and (6.5) elevon effectiveness.

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DYNA SOAR

MODEL 844-2050D

RIGID

$S_N = 345 \text{ FT}$
 $MAC = 246 \text{ IN}$
 $C.G. \sim .442$

$C.G. \sim .44 \text{ mac}$

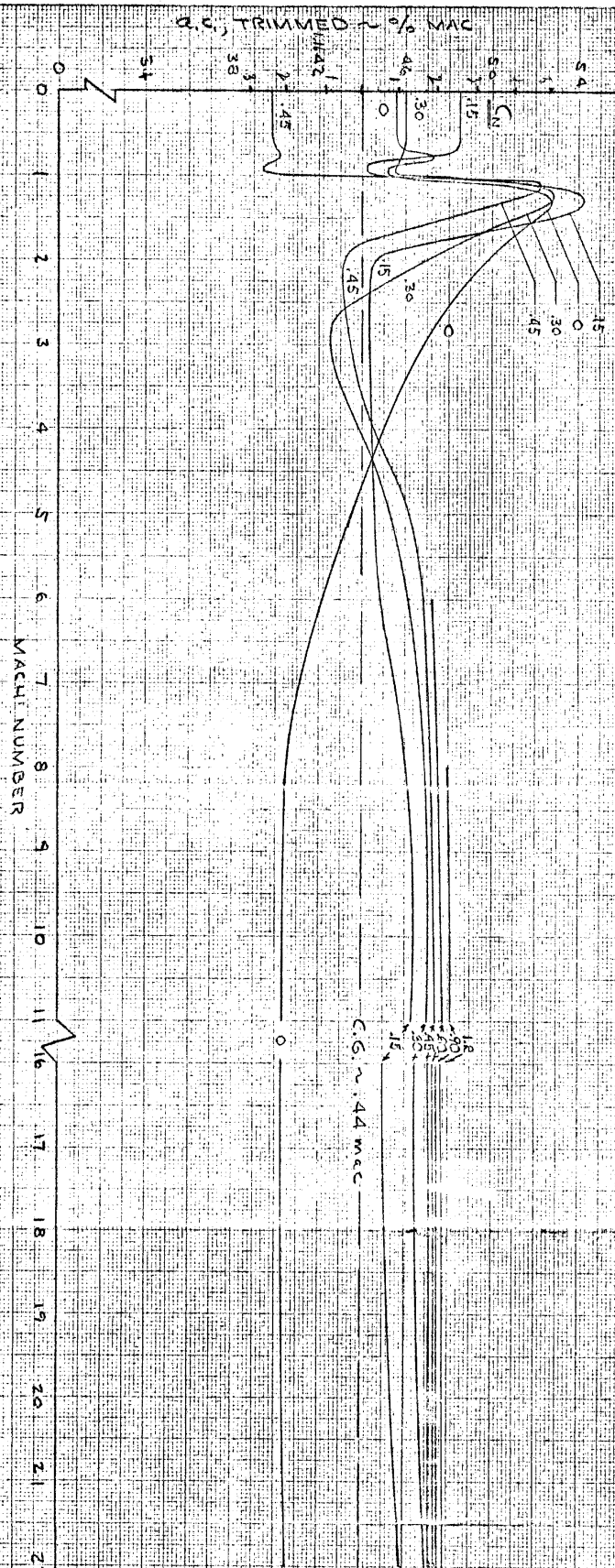


FIG. 6.1

CALC	Eq. 1/2	1/1	REVISED	DATE	AG DYNAMICS CENTER LONGITUDINAL
CHECK			EDK	11/16/61	
APPO				12/7/61	
APPO					
					PAGE
					C.3

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DYNA SOAR

MODEL 844-2050D

RIGID

REF. SW=34.7 FT
MAC=2.26 IN

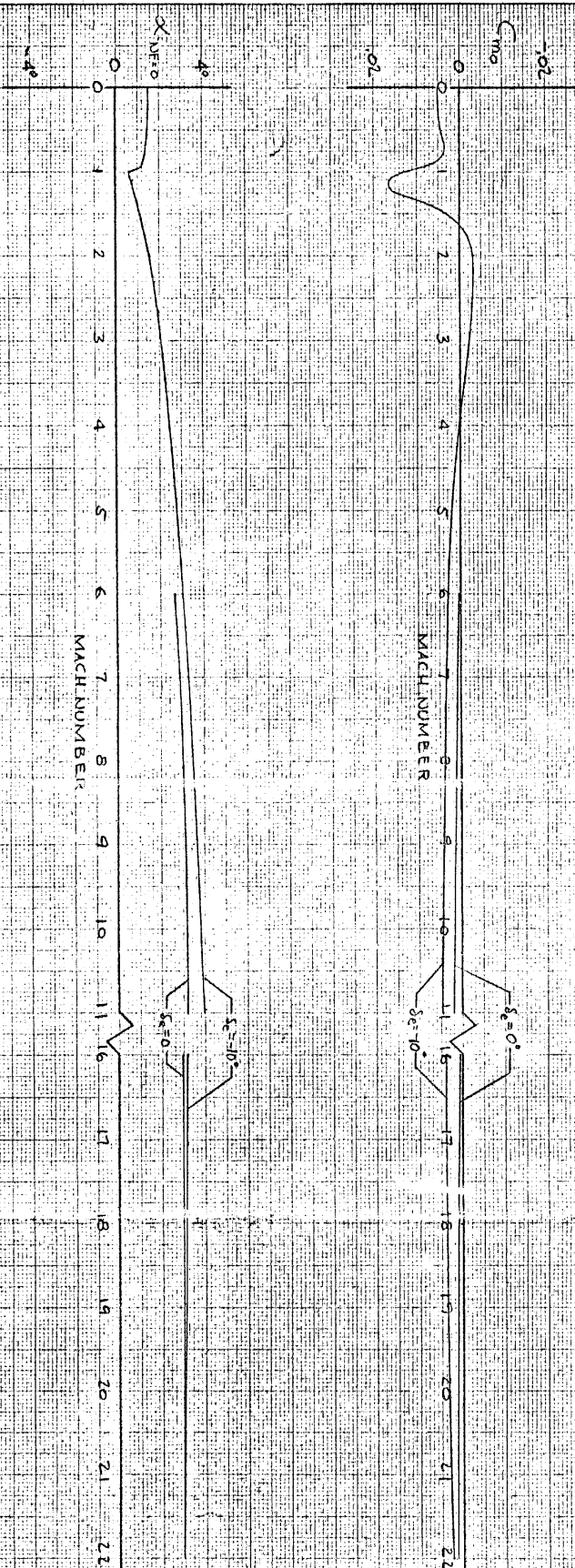


FIG. C3

DATE	CHKD/APPD	REVISED	DATE	ANGLE OF ATTACK AND PITCHING MOMENT AT ZERO NORMAL FORCE	Eqd 2650D
CHECK					DC-80065
APPD					PAE
APPD					6.5

ω, B, V, E_7

ω, B, V, E_7

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DYNA SOAR
MODEL 844-2050D
RIGID

REF: SW = 345 FT
MAC = 246 IN
C.G. = 44.2

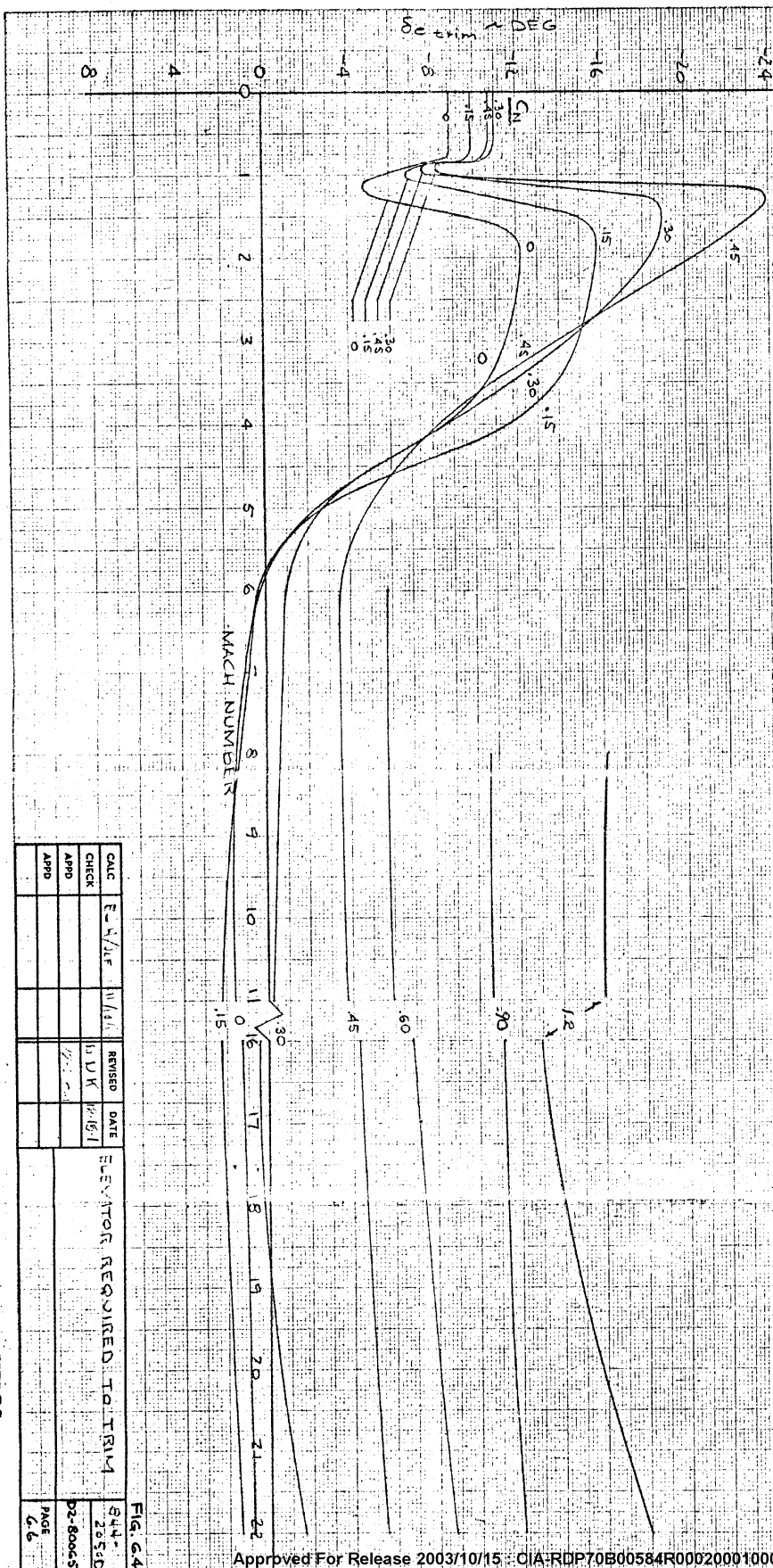


FIG. 64

CALC	CHK	APPD	DATE	REVISD	ELEVATOR REQUIRED TO TRIM
E-4/15	11/14	11/15	11/15	11/15	11/15
CHK					
APPD					
APPD					

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80

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DYNA SCAR

MODEL 899-2050 D

RIGID

REF. SW = 395 FT³
MAC = 246 IN
CE = 45.8 FT³ (TWA ELEVONS)

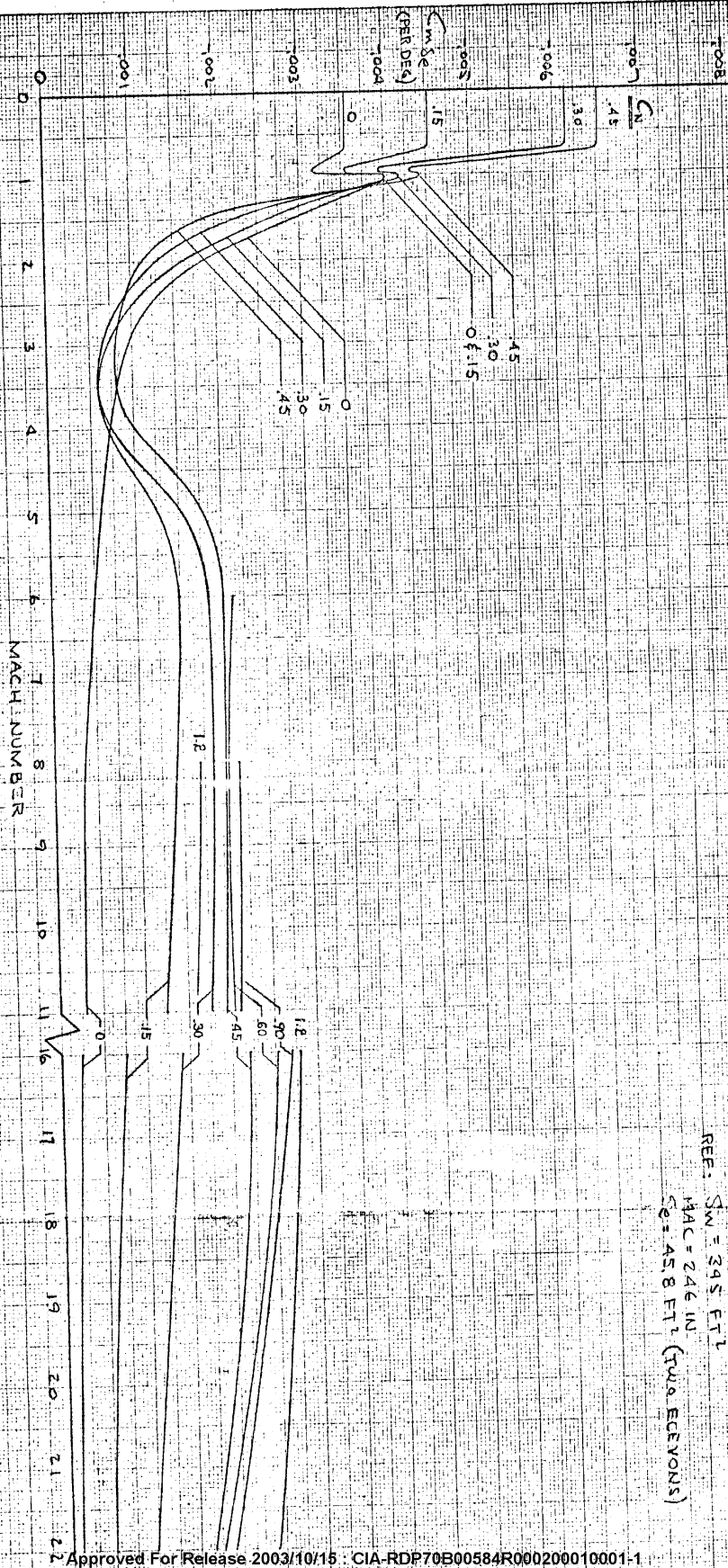


FIG. C5

CALC	CHK	DATE	REVISED	DATE	ELEVON EFFECTIVENESS	PAGE
844-	2050 D					6.7
844-	2050 D					6.7
844-	2050 D					6.7

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6.1.1 LANDING SPEED

Longitudinal stability and elevon effectiveness plots are presented in Figures 6.6 for the glider at a Mach number typical of landing speed. The trimmed normal force coefficients available at any angle of attack at landing speed are shown in Figure 6.7. These data were determined from test 685 in the Boeing Transonic Wind Tunnel and modified to the revision D configuration through the application of data from Boeing Transonic test 682.

The change in stability and control effectiveness with landing gear extended in the presence of a ground plane is shown in Figure 6.6. This effect was determined from wind tunnel tests in the Boeing Transonic Wind Tunnel on a similar configuration and this data was used to estimate the effect for the present configuration.

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2-3100

DYNA SOAR

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MODEL 844-2050D

$M=0.26$

RIGID

$\delta_r = .6/46$

LANDING GEAR DOWN
IN PRESENCE OF
GROUND PLANE

REF: $S_W = 345 \text{ FT}^2$
 $MAC = 246 \text{ IN}$

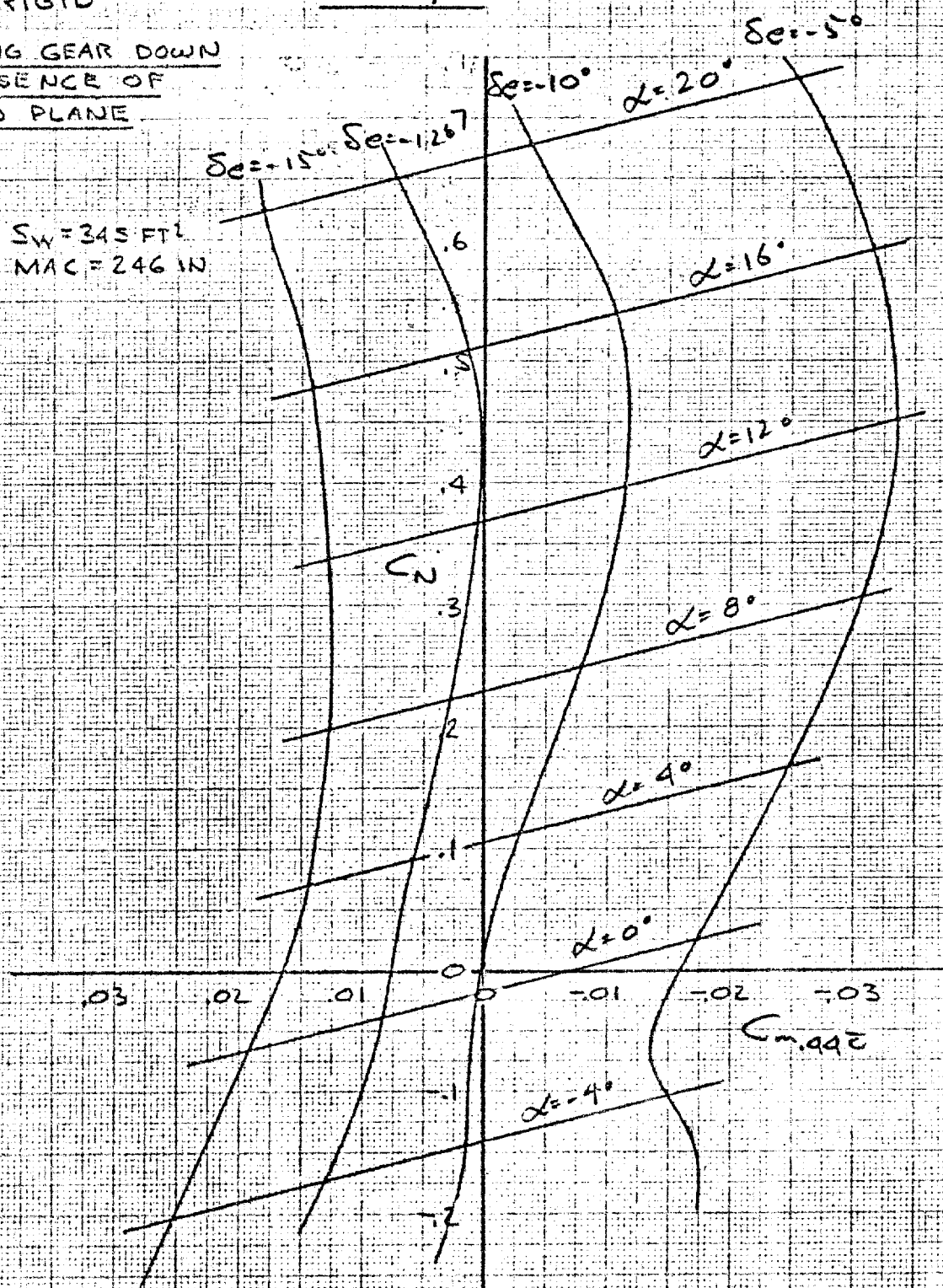


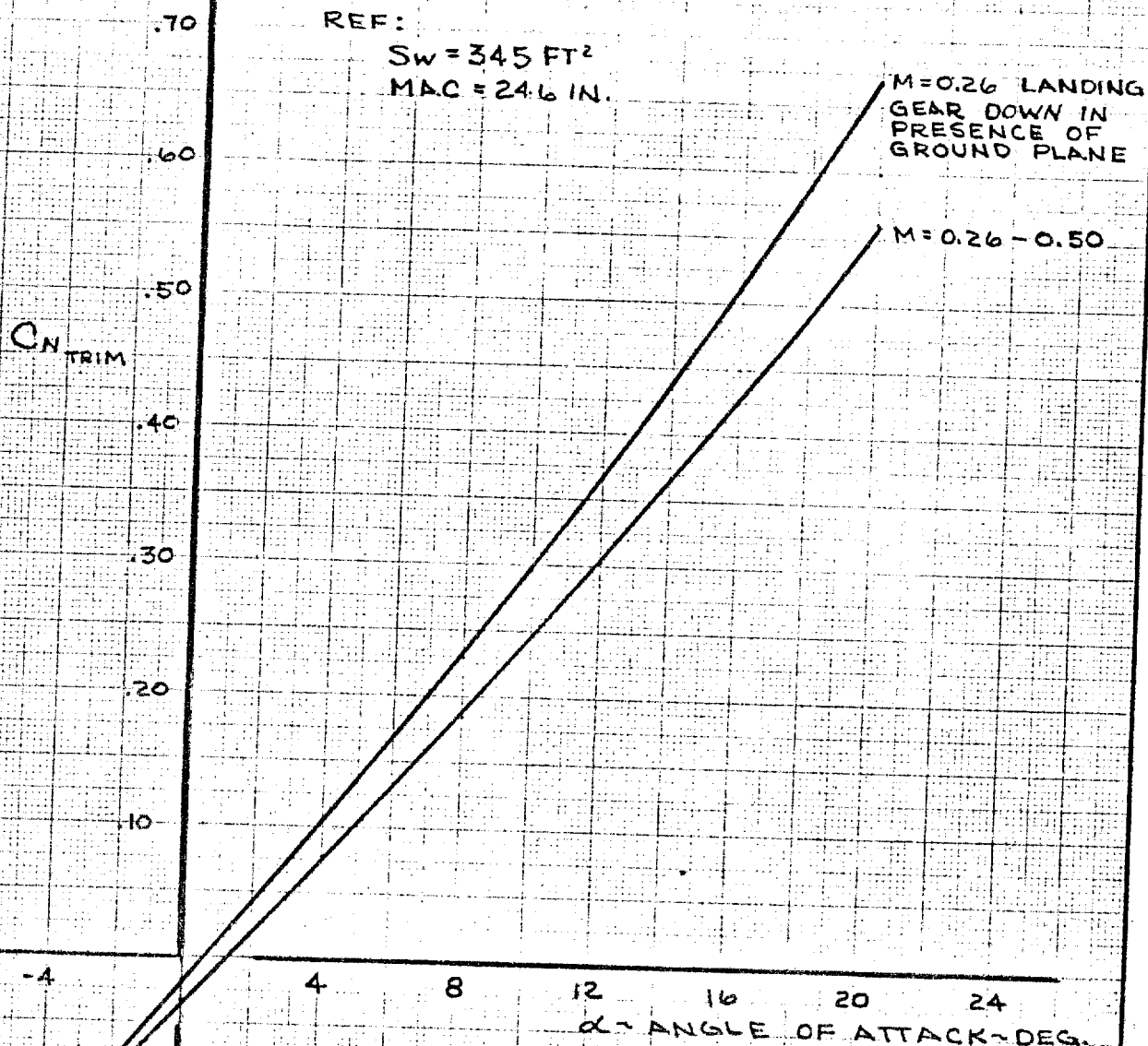
FIG. 6.6

CALC	EJH	11/7/11	REVISED	DATE	LONGITUDINAL STABILITY	844-2050D
CHECK			12-20-1		$M=0.26$	
APR					LANDING GEAR DOWN IN PRESENCE OF GROUND PLANE	D2-80065
APR					BOEING AIRPLANE COMPANY	PAGE 69

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DYNA SOAR
MODEL 844-20500

RIGID
LANDING SPEED
SR = -6/46



CALC	CLAAR	12-18-1	REVISED	DATE
CHECK			12-22-1	
APR				
APR				

TRIMMED NORMAL FORCE
LANDING SPEED

THE BOEING COMPANY

FIG. 6.7

844-20500

DZ-80065

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6.1.2 SUBSONIC - TRANSONIC SPEED

The longitudinal static stability and control effectiveness characteristics for the model 844-2050 revision D glider are shown in Figures 6.8 through 6.12, for the subsonic - transonic speed range. The corresponding trimmed normal force coefficients available at any angle of attack are shown in Figure 6.17. The data are based on Boeing Transonic Wind Tunnel tests 672 and 685 and modified by data from Boeing Transonic test 682.

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NO. D2-80065

$M = 0.26 - 0.50$

DYNA SOAR

$S_{10} = 6/16$

MODEL 844-2050D

RIGID

REF SW 245 FT
WAVE 286 IN

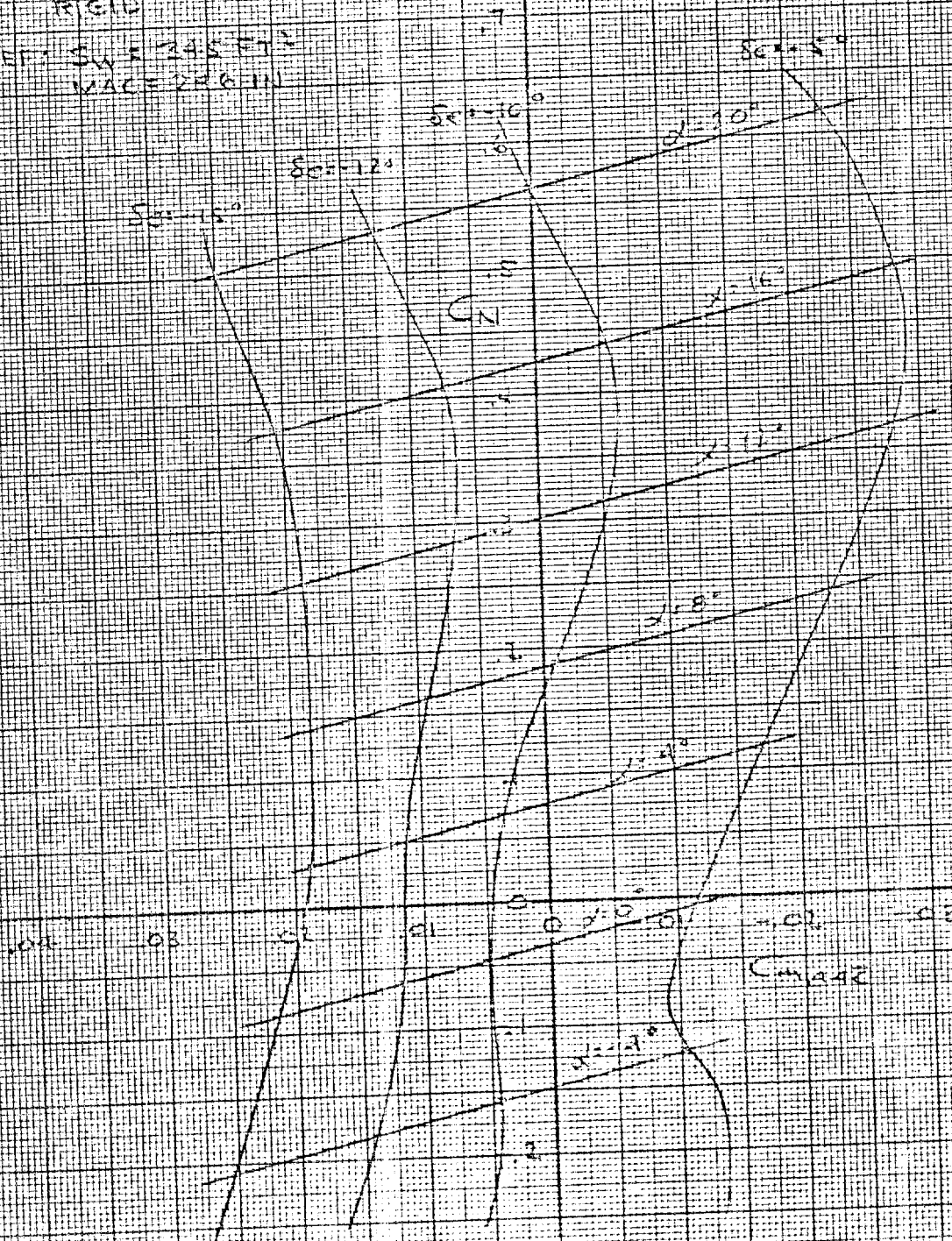


FIG. 6B

CALC	EJH	11/1/61	REVISED	DATE
CHECK			12/2/61	
APR				
APR				

LONGITUDINAL STABILITY
 $M = 0.26 - 0.50$

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844-
2050D

PAGE
6.12

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M=0.80

DYNA SOAR

S1-6/6

MODEL 844-2050D

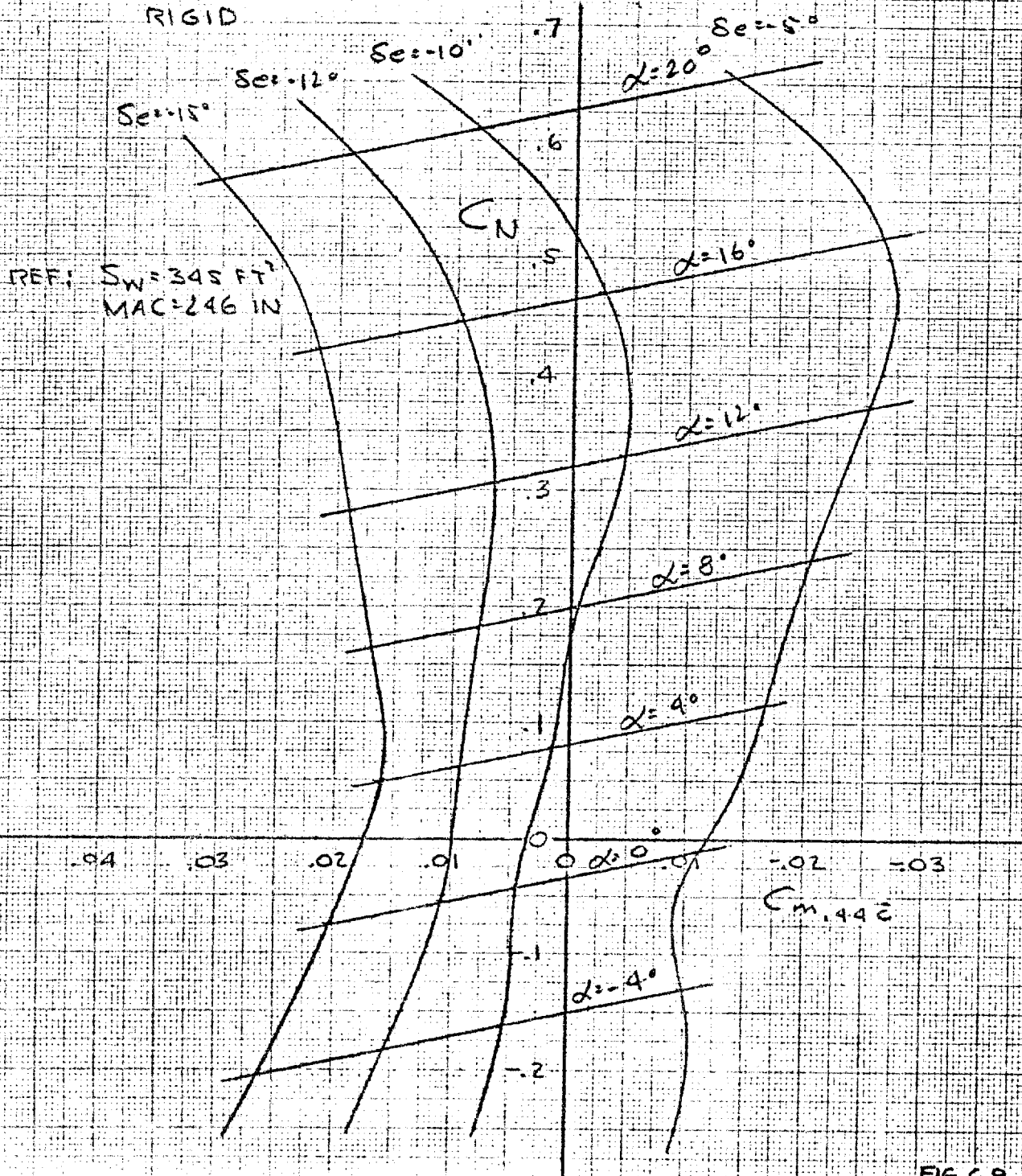
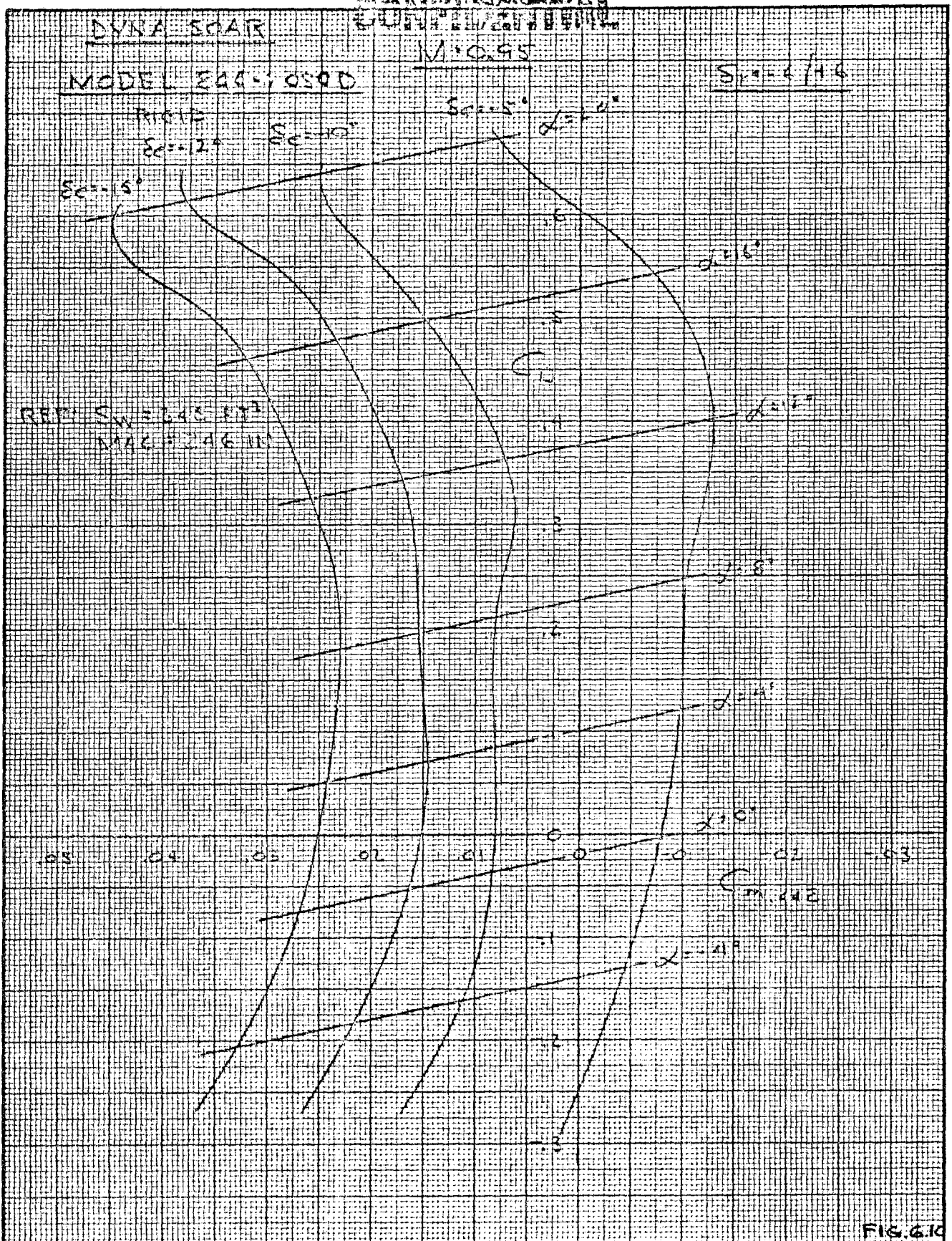


FIG. C.9

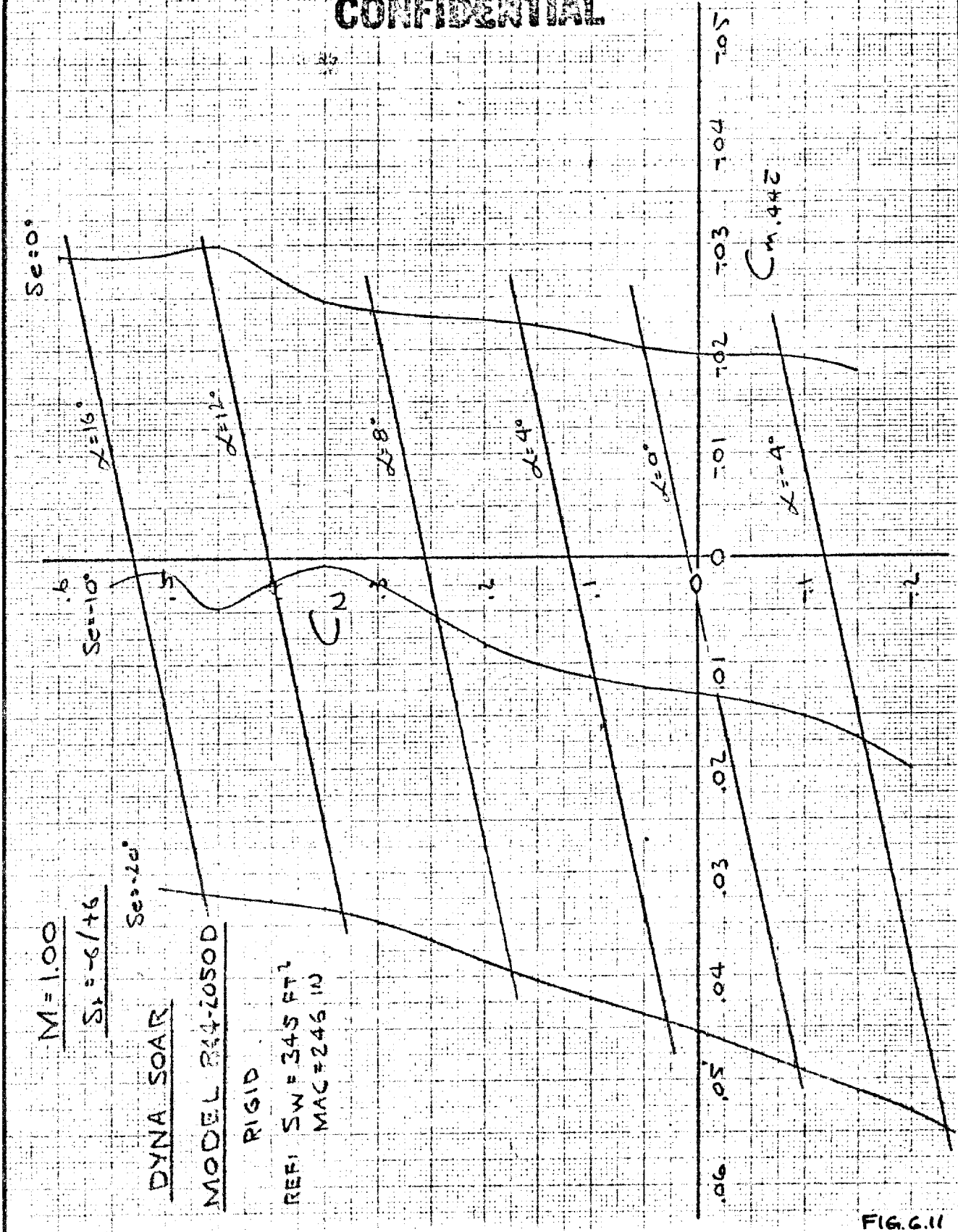
CALC	EJH	11/3/1	REVISED	DATE	LONGITUDINAL STABILITY	844-2050D
CHECK					M=0.80	D2-80065
APR					BOEING AIRPLANE COMPANY	PAGE
APR						6.13

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CALC	EJM	11/3/1	REVISED	DATE	LONGITUDINAL STABILITY M=0.95	844- 2050D
CHECK						
APR					THE BOEING COMPANY	PAGE 6.14
APR						

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$M = 1.00$

$S_1 = -6/46$

$S_2 = 20^\circ$

DYNA SOAR

MODEL 844-2050D

RIGID

REF: SW = 345 FT²

MAC = 246 IN

FIG. 6.11

CALC	EJ-M	11/8/1	REVISED	DATE	LONGITUDINAL STABILITY M=1.00	844-2050D
CHECK			12-20-1			
APR						02-80065
APR					THE BOEING COMPANY	PAGE 6.15
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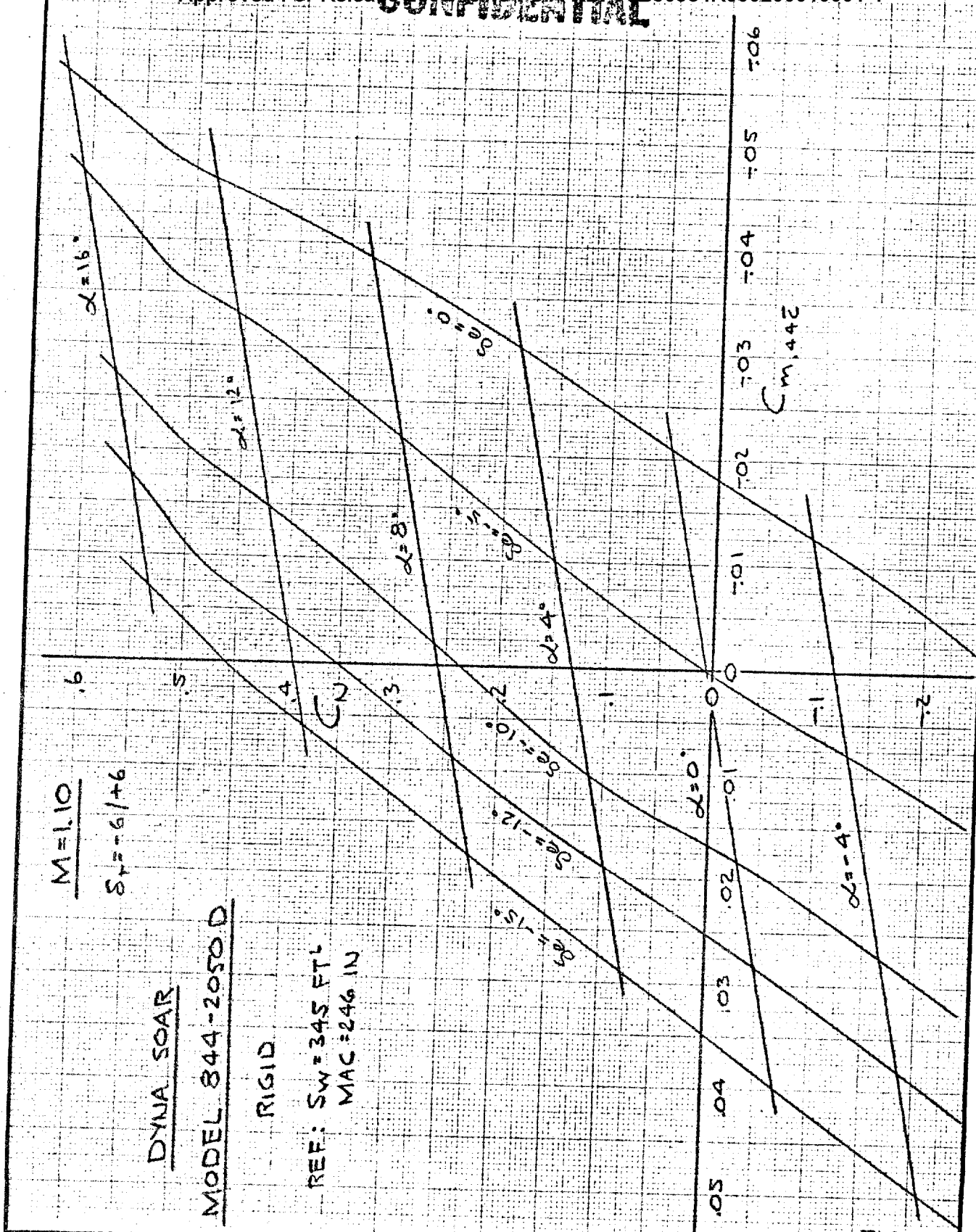


FIG. C.12

CALC	EJH	11/2/1	REVISED	DATE
CHECK			12/27/1	
APR				
APR				

LONGITUDINAL STABILITY
 $M=1.10$

844-2050D

02-80065

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DYNA SOAR

MODEL 844-2050D

RIGID

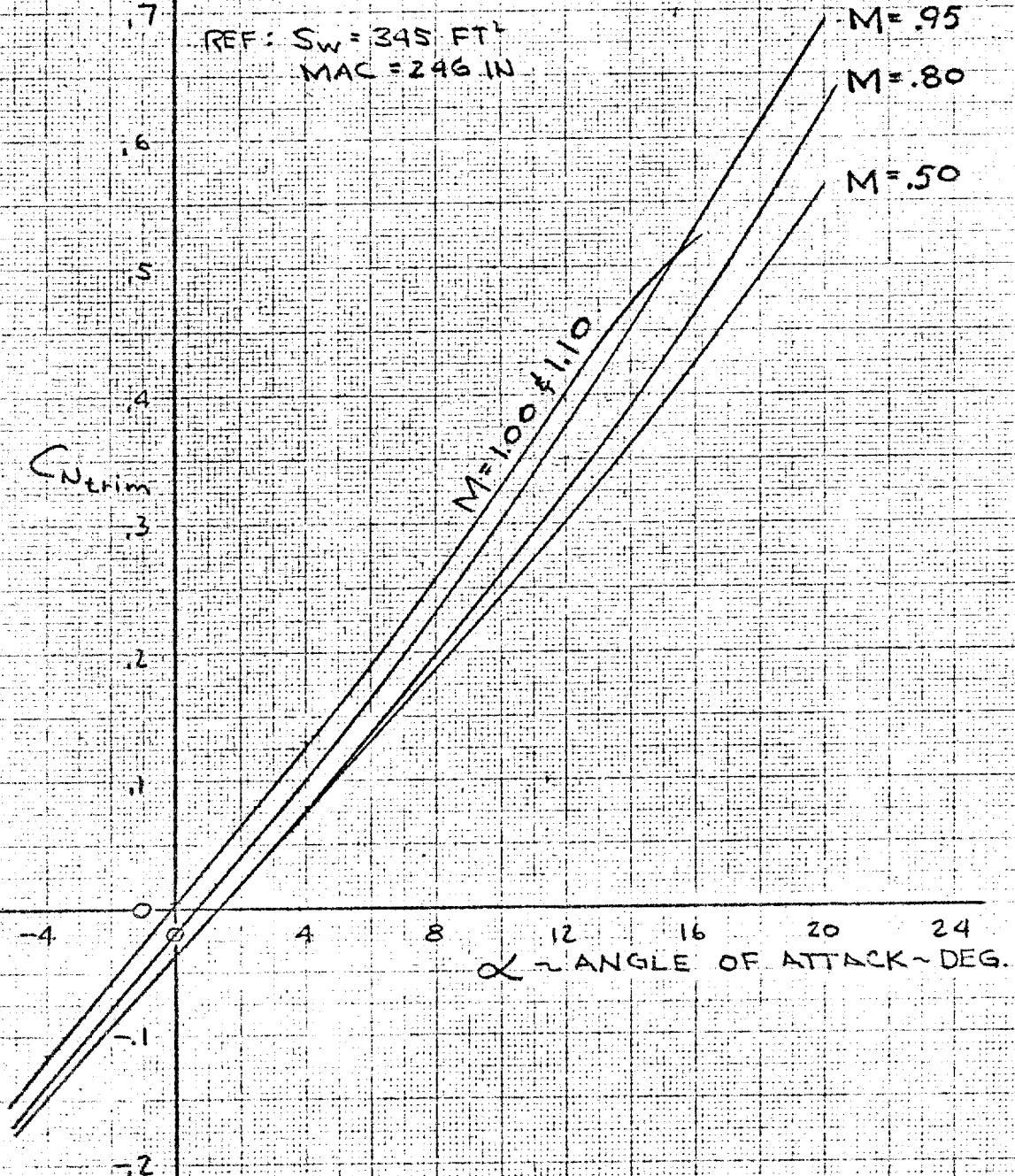


FIG. G.13

CALC	EJH	11/9/61	REVISED	DATE	TRIMMED NORMAL FORCE	844-2050D
CHECK			2-5-61		SUBSONIC - TRANSONIC	02-80065
APR						PAGE
APR					THE BOEING COMPANY	6.17

W.B.V.B.E.

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6.1.3 SUPERSONIC SPEED

The longitudinal static stability and control characteristics for the model 844-2050 revision D glider configuration are shown in Figures 6.14 through 6.16 for supersonic speeds. The corresponding normal force coefficients available at any angle of attack are shown in Figure 6.17. These data are based on Boeing Supersonic Wind Tunnel tests 105 and 113.

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$M=1.4$

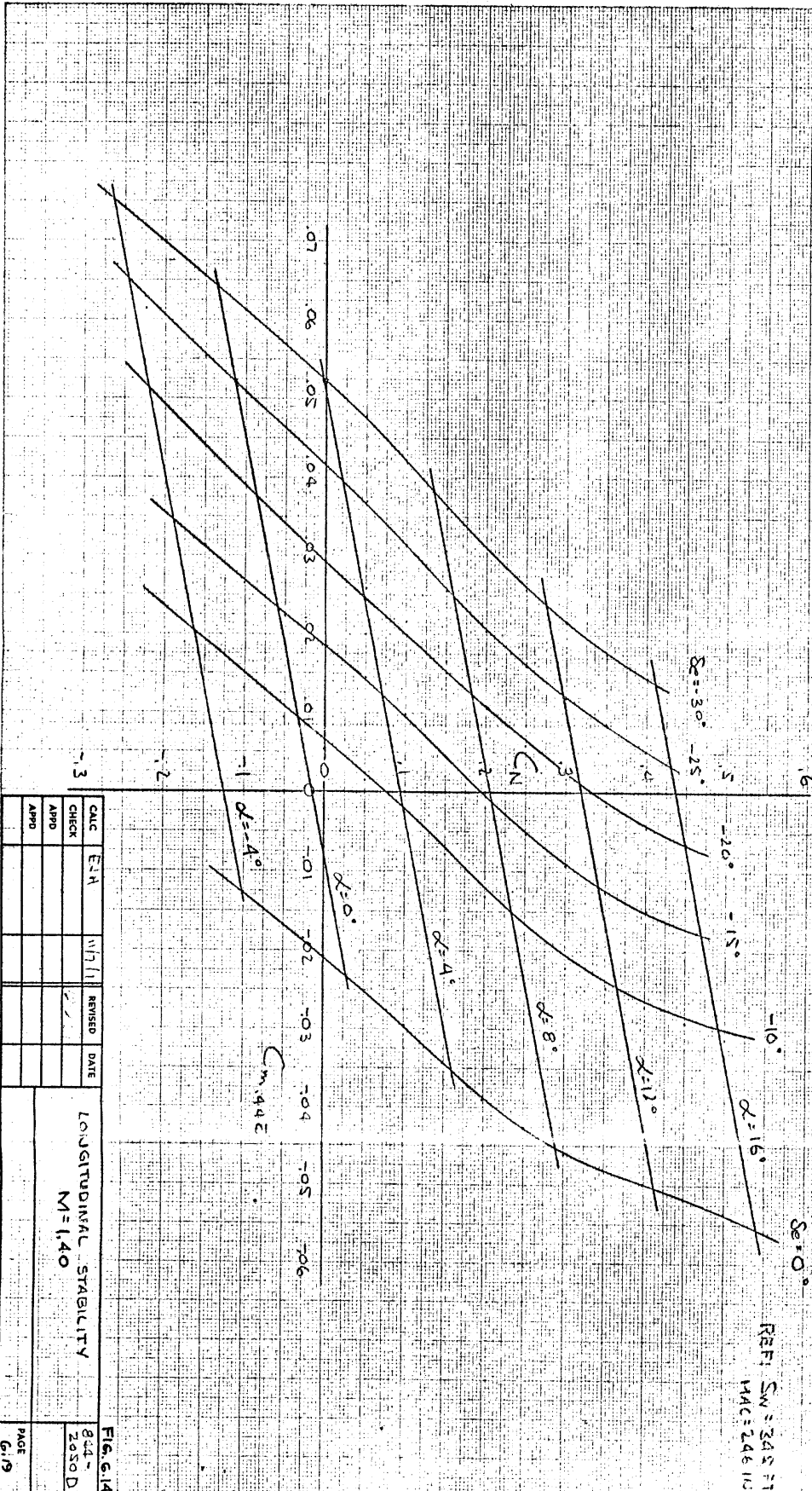
$\delta P = -6/16$

DMA SOAR

MODEL B44-2050D

RIGID

REF: $S_{W} = 345 \text{ ft}$
 $MAC = 246 \text{ in}$



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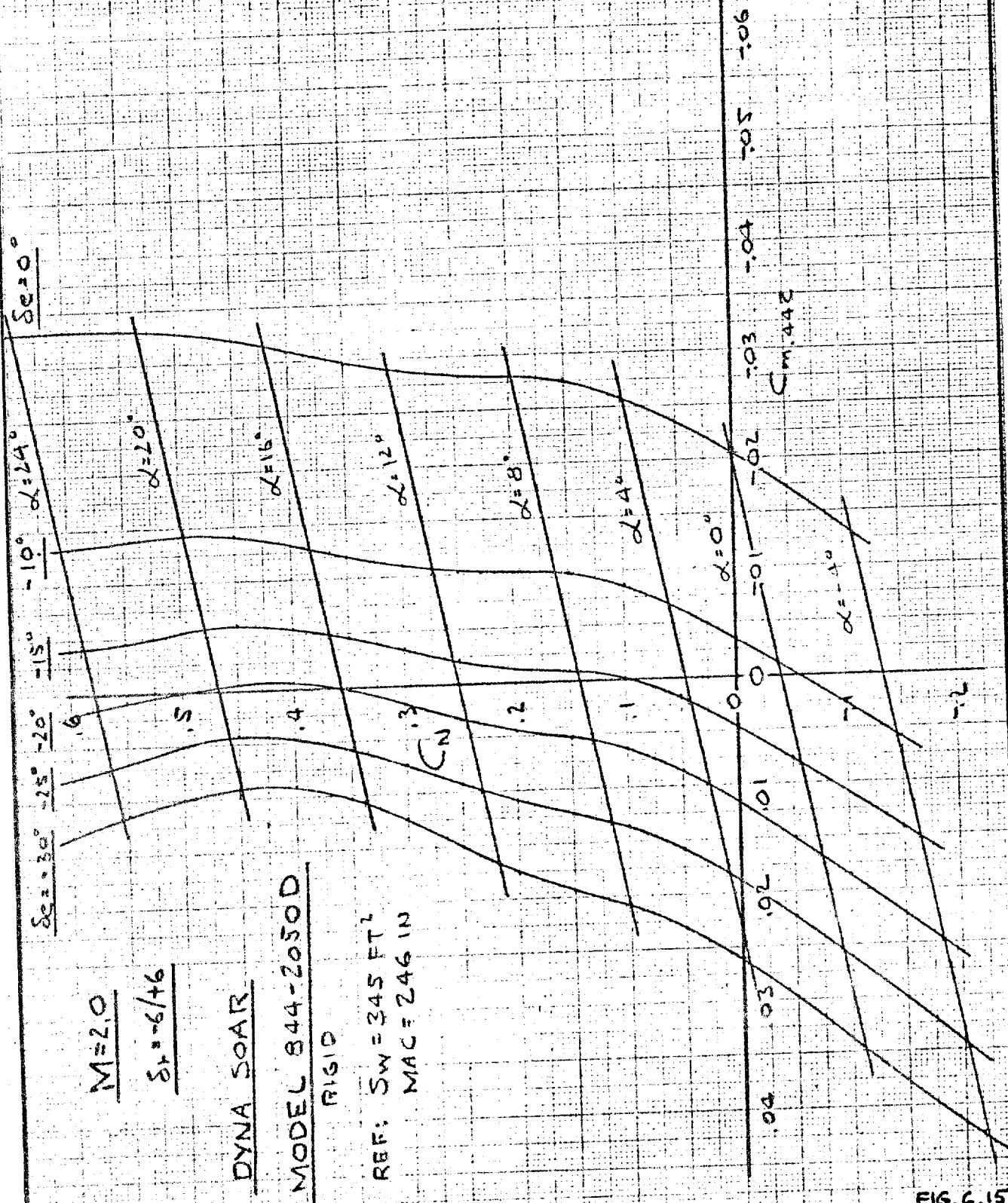


FIG. 6.15

CALC	EJH	11/7/1	REVISED	DATE
CHECK			12/22/1	
APR				
APR				

LONGITUDINAL STABILITY
 $M=2.0$

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2050D
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6.20

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$M=3.50$

$\delta_t = 0/0$

DYNA SOAR

MODEL 844-2050D

RIGID

REF: $S_W = 345 \text{ FT}^2$
 $MAC = 246 \text{ IN}$

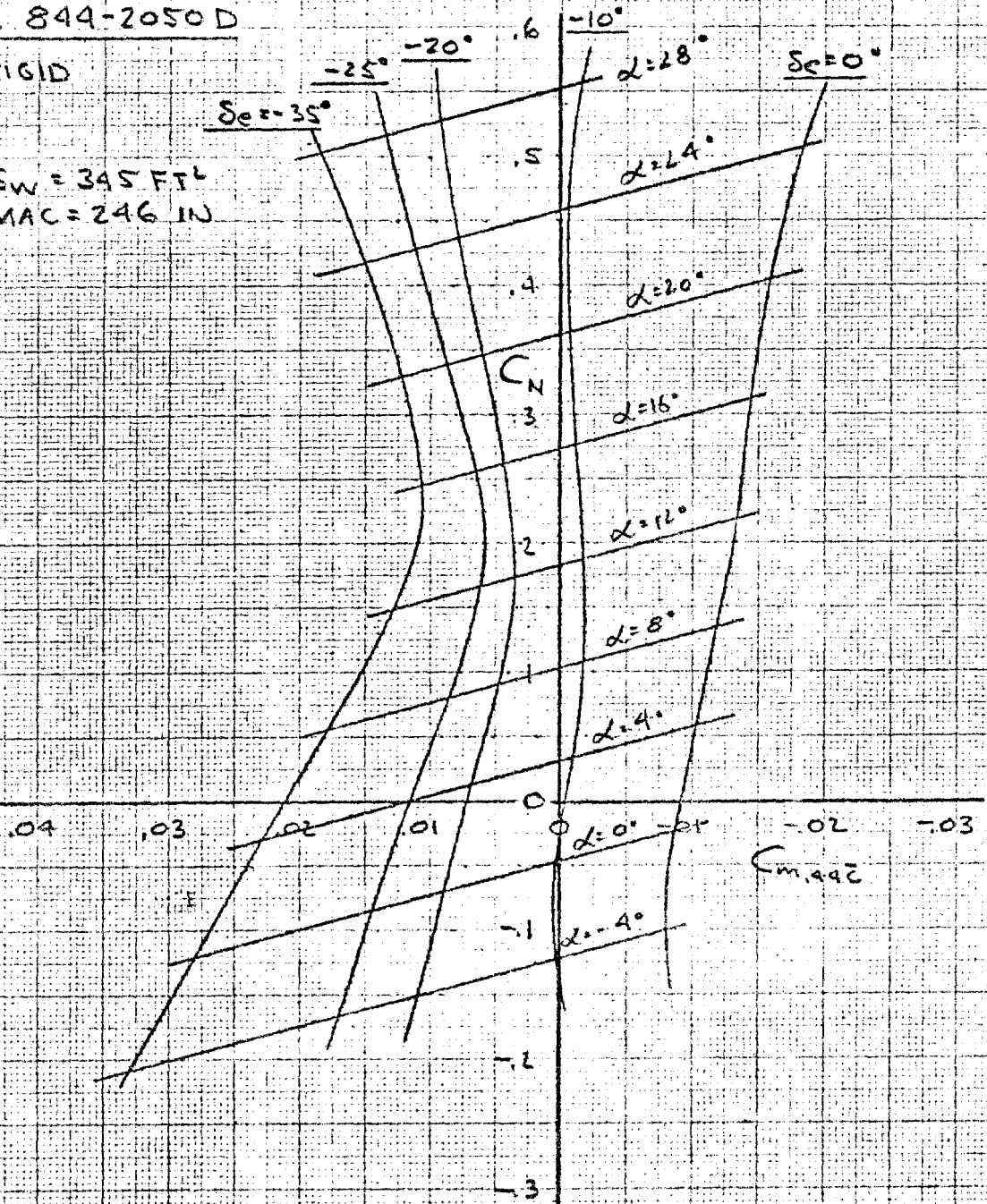


FIG. 6.16

CALC	EJH	11/24/61	REVISED	DATE	LONGITUDINAL STABILITY $M=3.50$	844-2050D
CHECK						D2-80065
APR					THE BOEING COMPANY	PAGE 6, 21
APR						

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DYNA SOAR

MODEL 844-2050D

RIGID

REF: $S_W = 345 \text{ FT}^2$
 $MAC = 246 \text{ IN}$

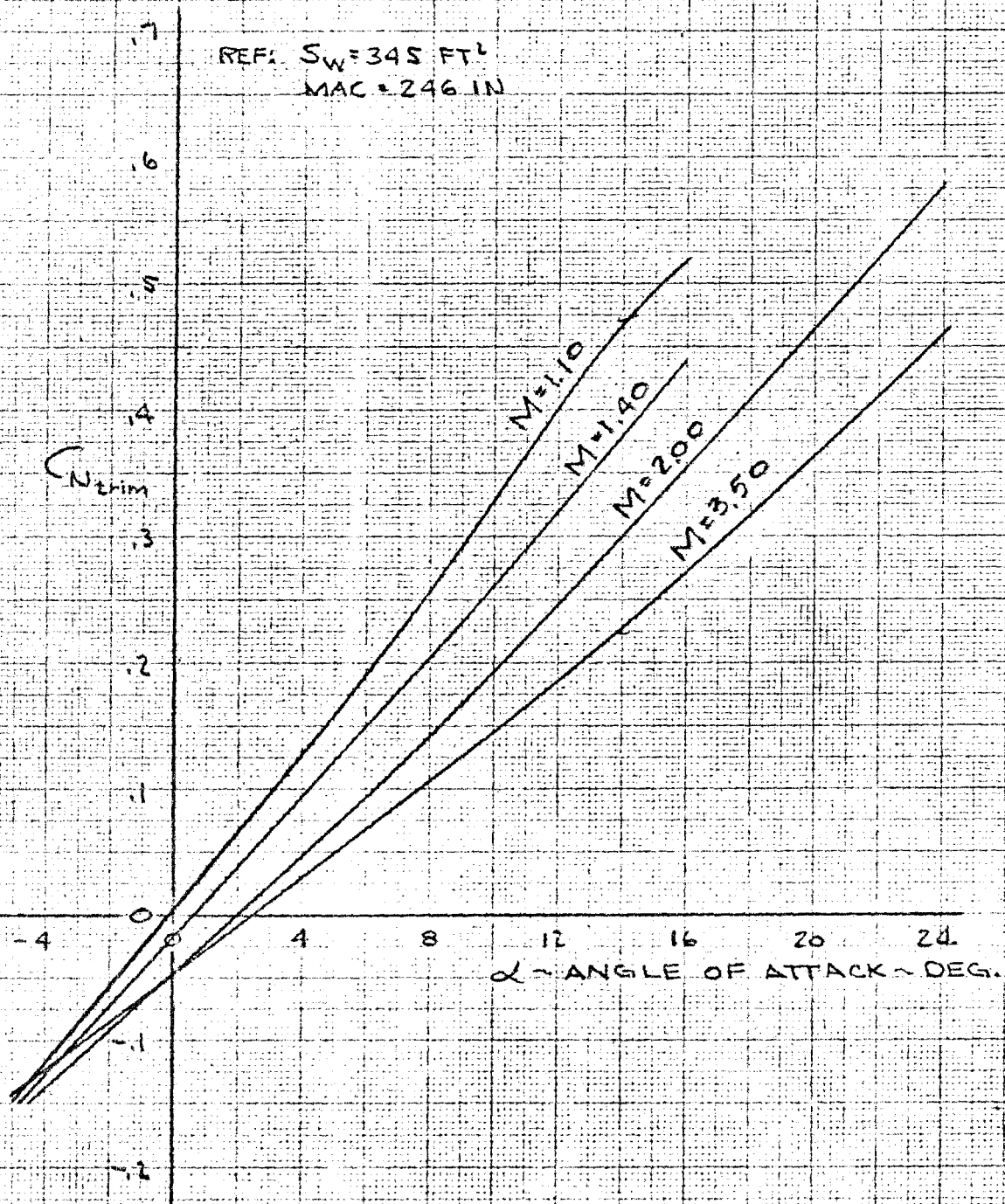


FIG. 6.17

CALC	EJH	11/1/61	REVISED	DATE	TRIMMED NORMAL FORCE SUPERSONIC THE BOEING COMPANY	844-2050D
CHECK						D2-80065
APR						PAGE
APR						6.22

W.B. V6E7

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CONFIDENTIAL**6.1.4 HYPERSONIC SPEED**

Longitudinal static stability and control characteristics for model 844-2050 D glider configuration are shown in Figures 6.18 through 6.62 for hypersonic speeds. Curves of longitudinal stability, longitudinal aerodynamic center, trim requirements, trimmed normal force and control effectiveness are shown at individual Mach numbers of 6, 8, 9, 11, 16 and 22 with two Reynolds numbers considered at a Mach number of 9. Figures are based on modified test data obtained at Jet Propulsion Laboratory 21" Hypersonic Wind Tunnel (M = 6, 9, 11), Arnold Center Tunnel B (M = 8) and Boeing Hot Shot Wind Tunnel (M = 16, 22). Theoretical corrections to test data have been made at low angles of attack to account for configuration modifications consisting of an upper aft body flare and a thicker vertical tail.

Low angle of attack data ($\alpha \leq 20^\circ$) at M = 6, 9, 11 and high angle of attack data ($\alpha \geq 20^\circ$) at M = 16, 22 have been extrapolated on the basis of M = 8 data, previous wind tunnel tests of similar configurations and theoretical estimates.

Basic hypersonic test models were thermally deformed configurations ("hot shape") which had a 4 degree nose inclination as opposed to the cold 3 degree shape. Figures for both "hot" and "cold" configurations are shown for Mach numbers of 6, 8, and 9 with only "hot shape" shown for higher Mach numbers.

The continuous flow facilities at Mach numbers of 11 and below are capable of matching flight conditions and yield consistent data. At high Mach numbers "hot shot" data show a much higher degree of scatter. While the "hot shot" test conditions cannot duplicate flight enthalpy and slight conical nozzle effects are present, these deviations are negligible on stability and control characteristics in comparison to data scatter.

In the rarefied gas regime, curves are presented at intermediate altitudes between the "cold shape" continuum flow values at 250,000 feet and the free molecule values at 500,000 feet. These data are assumed to apply in the speed regime above 20,000 feet per second. The data shown at 250,000 feet altitude are from test data in the Boeing Hot Shot tunnel at a Mach number of 22. Free molecular flow was assumed to exist at 500,000 feet altitude. Full momentum transfer of the particles was assumed. The effect of re-emission was considered to be negligible. At intermediate altitudes the Knudsen number, which may be considered a similarity number for rarefied flows, was used to establish a rational interpolation. The free molecule values of pitching moment and normal force were approached as the Knudsen number became large. The incremental modification to the "cold shape" continuum data was obtained in the following manner;

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6.1.4 HYPERSONIC SPEED (Cont'd)

$$\frac{K}{K+1} (\Delta C_M)_{\text{CONT-FM}} = \Delta C_M$$

$$\frac{K}{K+1} (\Delta C_N)_{\text{CONT-FM}} = \Delta C_N$$

$$\text{WHERE } K = \frac{\lambda}{d}$$

 $\lambda = \text{MEAN FREE PATH}$

$$d = \bar{c} \sin \alpha \quad \alpha \geq 15^\circ$$

$$d = \bar{c}_w \quad \alpha < 15^\circ$$

 $\bar{c} = \text{MEAN AERODYNAMIC CHORD}$
 $\bar{c}_w = \text{WING THICKNESS}$

At altitudes up to 350,000 ft where significant continuum effects may still exist, a decrease in elevon effectiveness was considered. A thickening of the large hypersonic boundary layer as it expands around the upward deflected elevon will decrease the effective angle of expansion. By use of a computer program which numerically integrates the boundary layer equations, References 1 & 2, momentum thicknesses were obtained before and after the expansion. Loss in effectiveness was then obtained from the effective angle of expansion along the chord of the elevon in the form of $\frac{d\delta^*}{dx}$. Additional analytical and experimental work is continuing in this region of rarefied gas dynamics.

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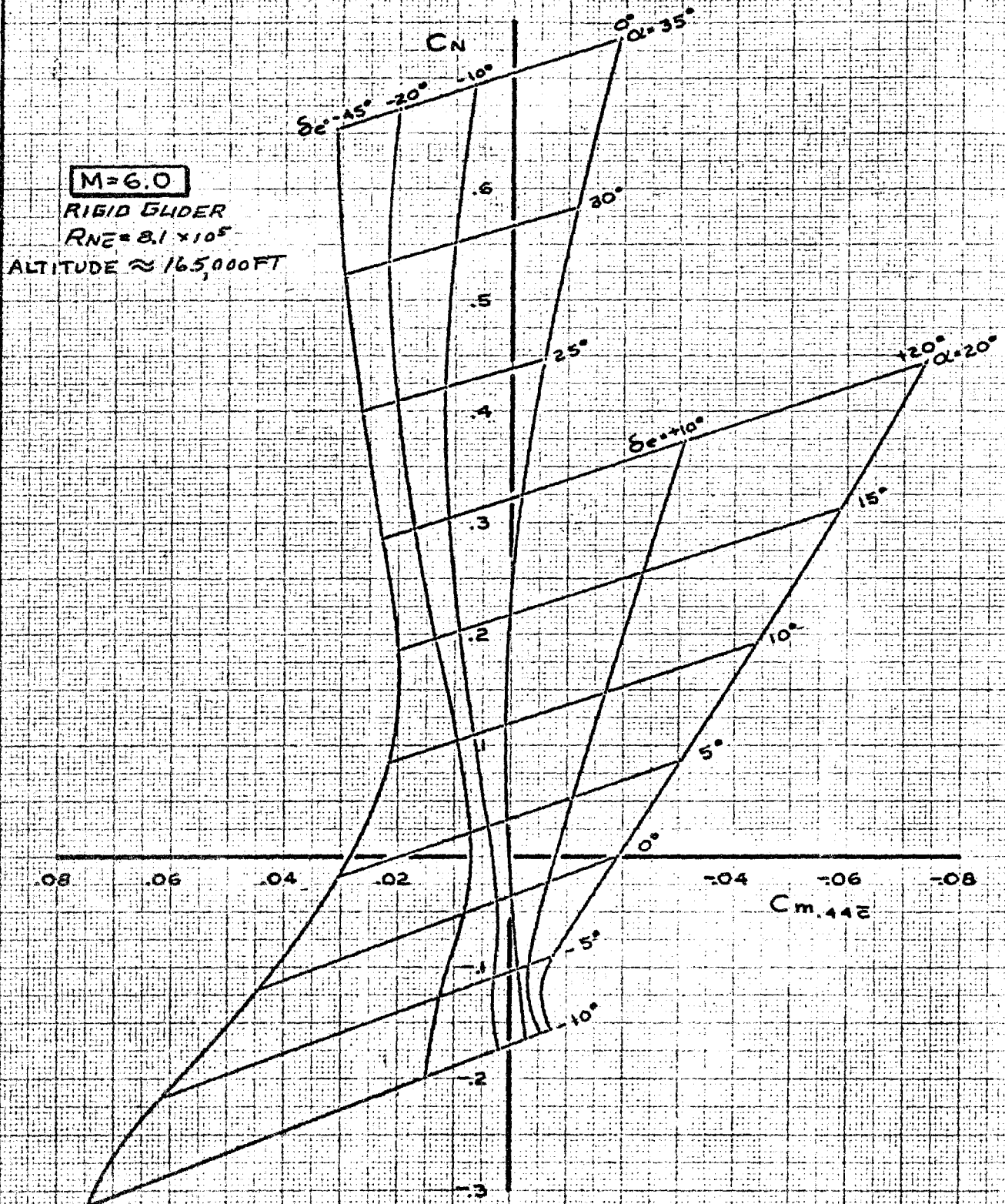


FIG. G.18

CALC	D. KATZ	11-17-61	REVISED	DATE	HOT SHAPE LONGITUDINAL STABILITY M = 6.0 THE BOEING COMPANY	844-20500
CHECK			12-2-61			D2-80065
APR						PAGE 6.25
APR						
TRACE	N.A.	11-17-61				

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M = 8.08

RIGID GLIDER

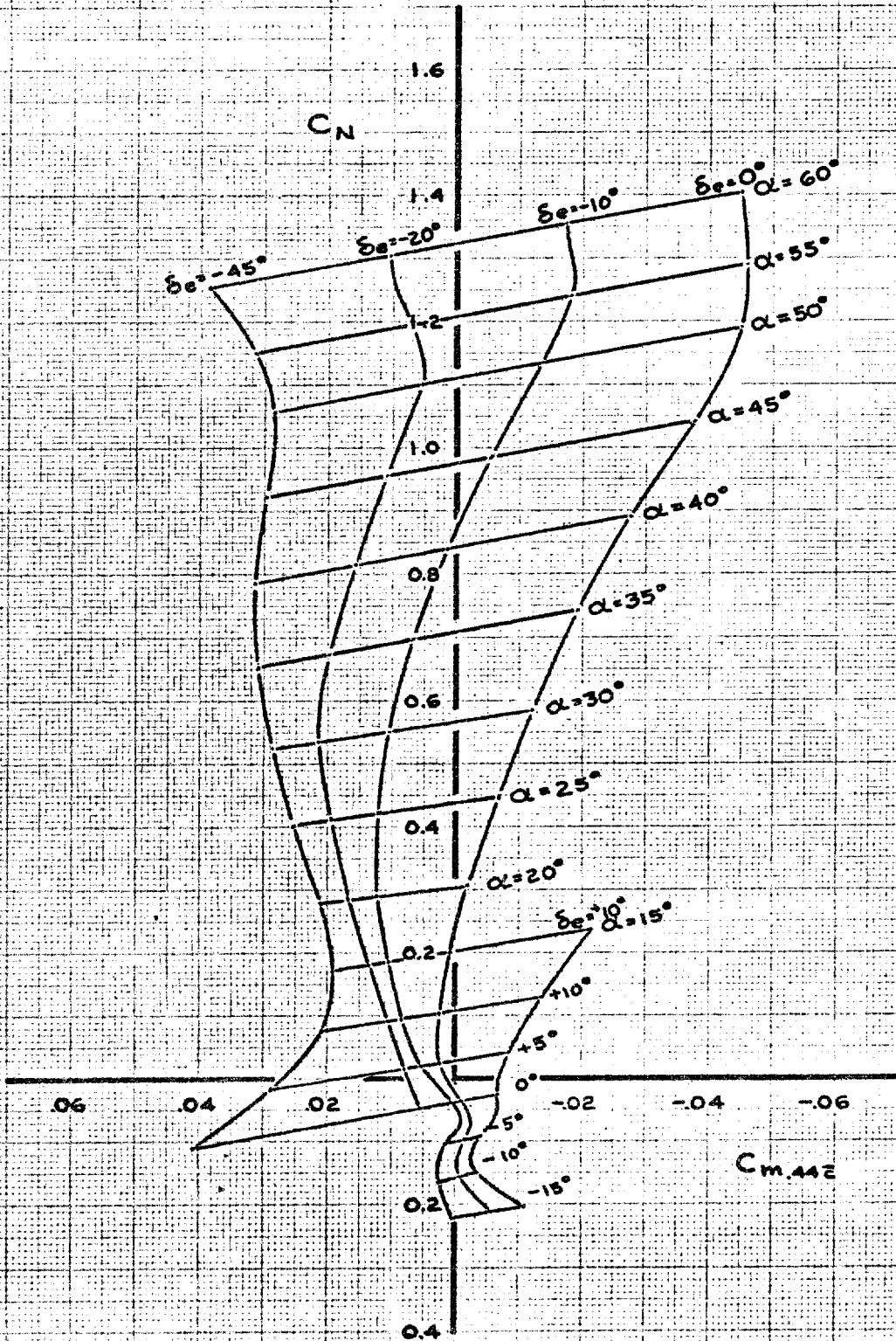


FIG. 6.19

CALC	J.L. FRANCIS	11-2-61	REVISED	DATE
CHECK			2201	
APR				
APR				
DRN	71.1	11-2-61		

**HOT SHAPE
LONGITUDINAL STABILITY
M = 8.08**

THE BOEING COMPANY

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2050 D
D2-80065
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M = 9.0

RIGID GLIDER

$RN_z \approx 4.5 \times 10^5$

ALTITUDE $\approx 195,000$ FT

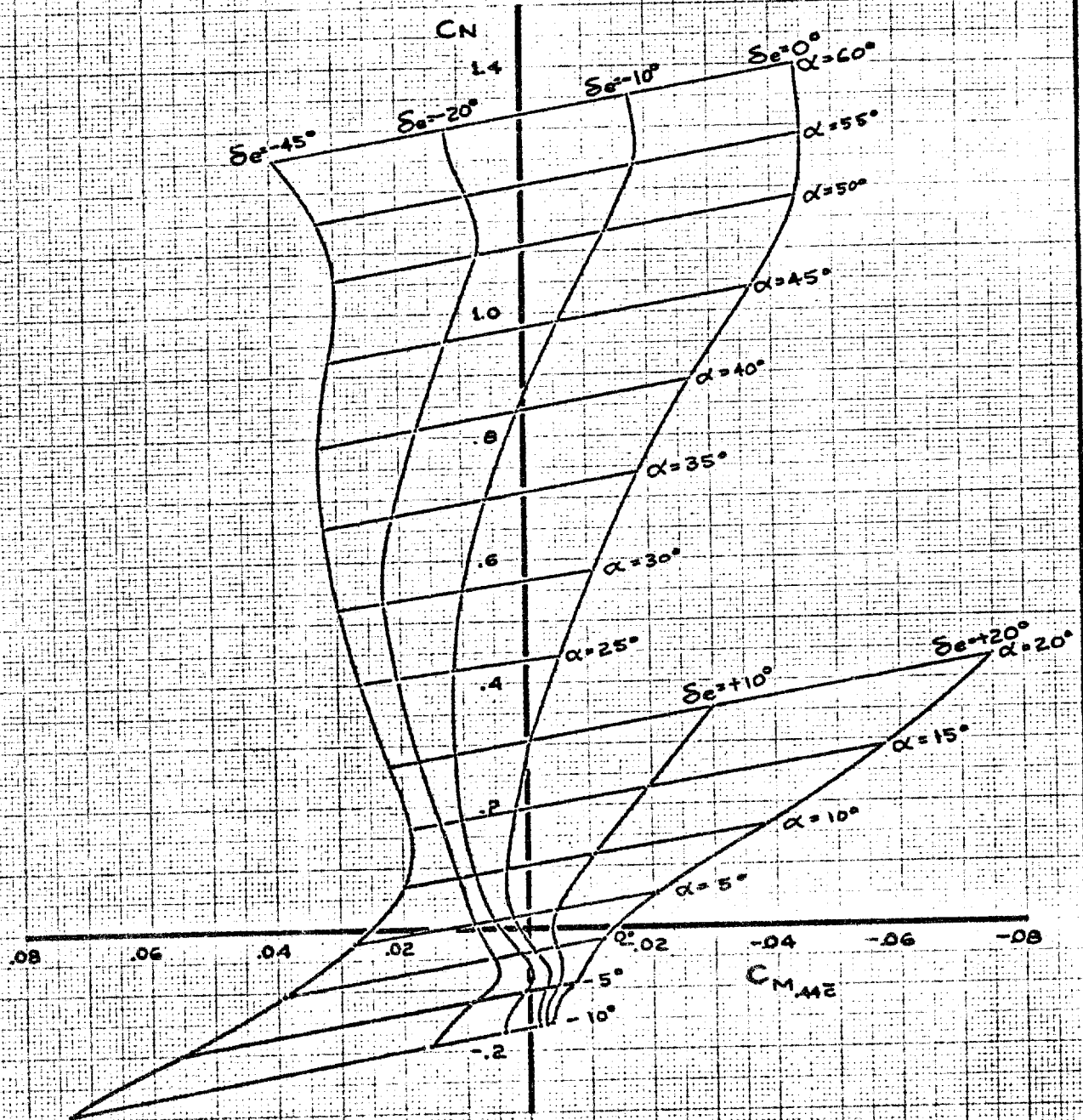


FIG. 6.20

CALC	J.L. FRANCIS	11/22/61	REVISED	DATE
CHECK				
APR				
APR				

**HOT SHAPE
LONGITUDINAL STABILITY
M = 9.0 LOW RN_z**

**844-2050 D
D2-80065
PAGE 6.27**

THE BOEING COMPANY

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CONFIDENTIAL **M = 9.0**

RIGID GLIDER
 $RNE = 8.1 \times 10^5$
 ALTITUDE $\approx 180,000$ FT

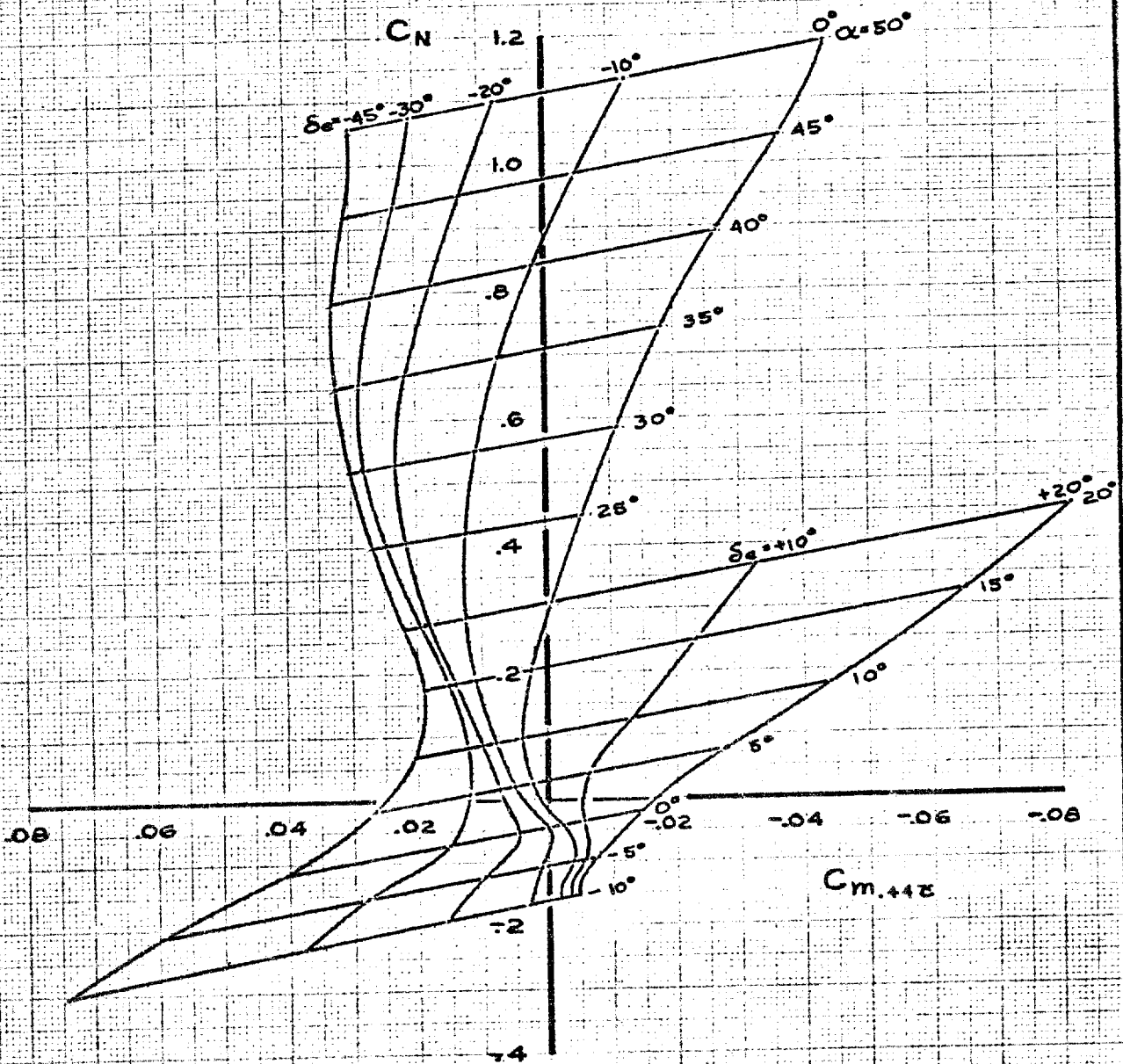


Fig. 6.21

CALC	J.L. FRANCIS	11/10/61	REVISED	DATE
CHECK				
APR				
APR				
TRACE	N.U.			

HOT SHAPE
 LONGITUDINAL STABILITY
 M = 9.0

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 20500
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 6.23

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$M = 11.0$

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RIGID GLIDER

$RN_z = 4.5 \times 10^5$

ALTITUDE $\approx 195,000$ FT

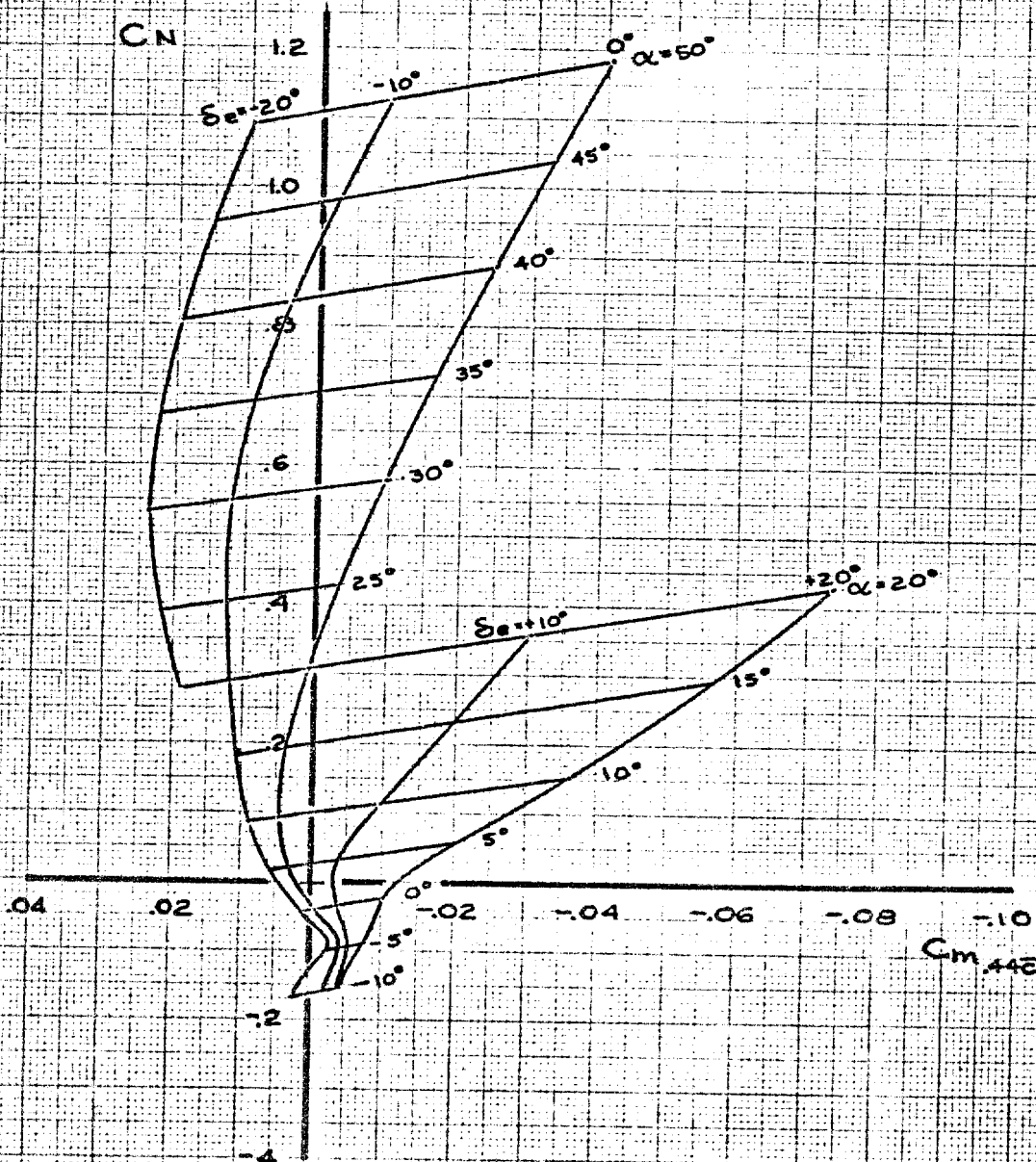


FIG. 6.22

CALC	D. KATZ	11-13-61	REVISED	DATE
CHECK			12-27-61	
APR				
APR				

HOT SHAPE
LONGITUDINAL STABILITY
 $M = 11.0$

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2050D
02-80065

TRACE N.W.
U3 4013 8000

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6.29

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M = 16.0

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RIGID GLIDER

$$R_{NE} = .164 \times 10^6$$

ALTITUDE \approx 236,000 FT.

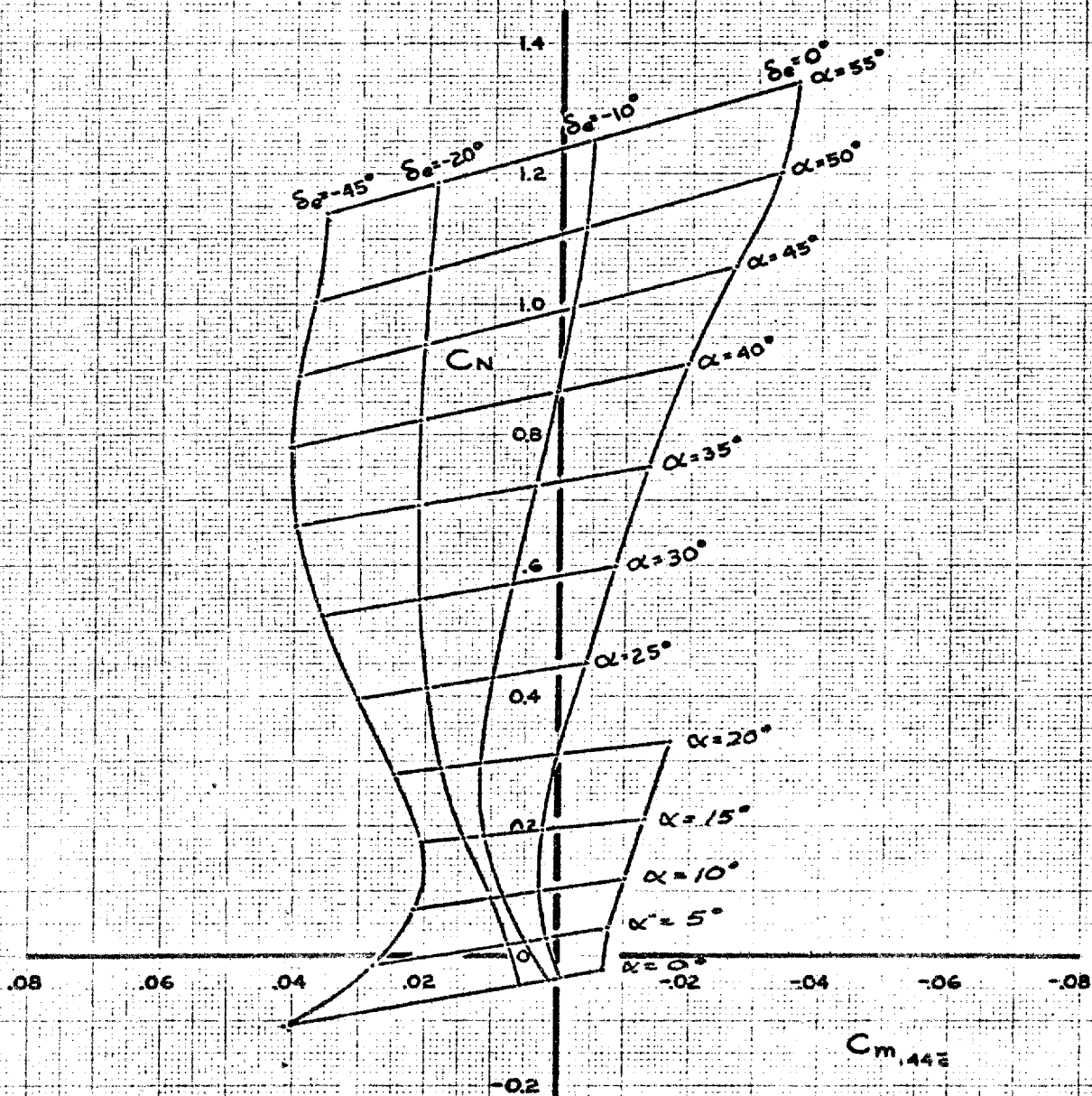


FIG. C.23

CALC	E. PIPER	(1-9-61)	REVISED	DATE
CHECK				
APR				
APR				
TRACE				

**HOT SHAPE
LONGITUDINAL STABILITY
M = 16.0**

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20500
D2-80065
PAGE
6.30**

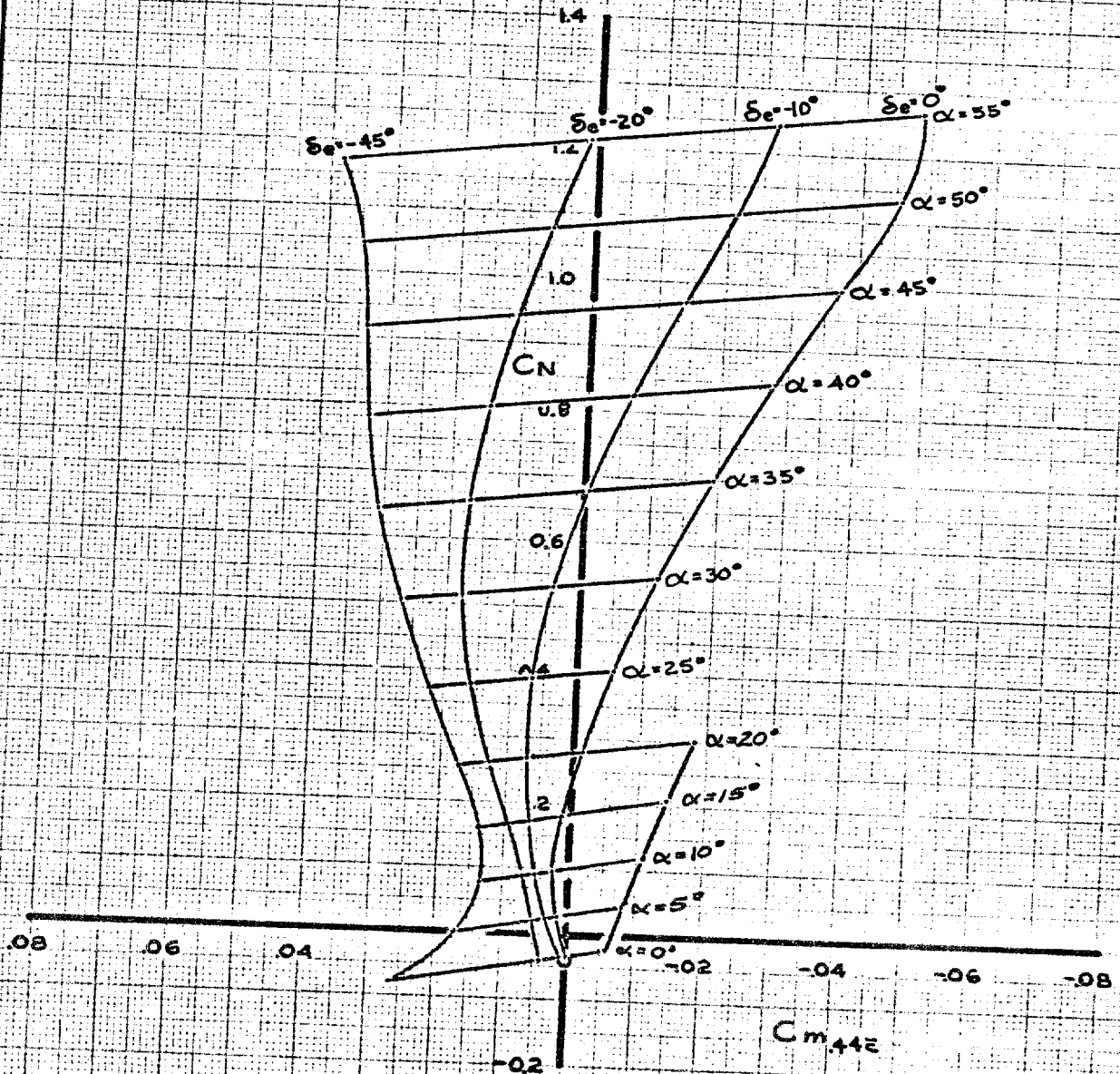
M=22.0

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RIGID GLIDER

$R_{N2} = .066 \times 10^6$

ALTITUDE $\approx 263,000$ FT.



CALC	E. PIPER	11-9-1	REVISED	DATE
CHECK				
APR				
APR				

HOT SHAPE
LONGITUDINAL STABILITY
M=22.0

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FIG. C.24

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20500

D2-80065

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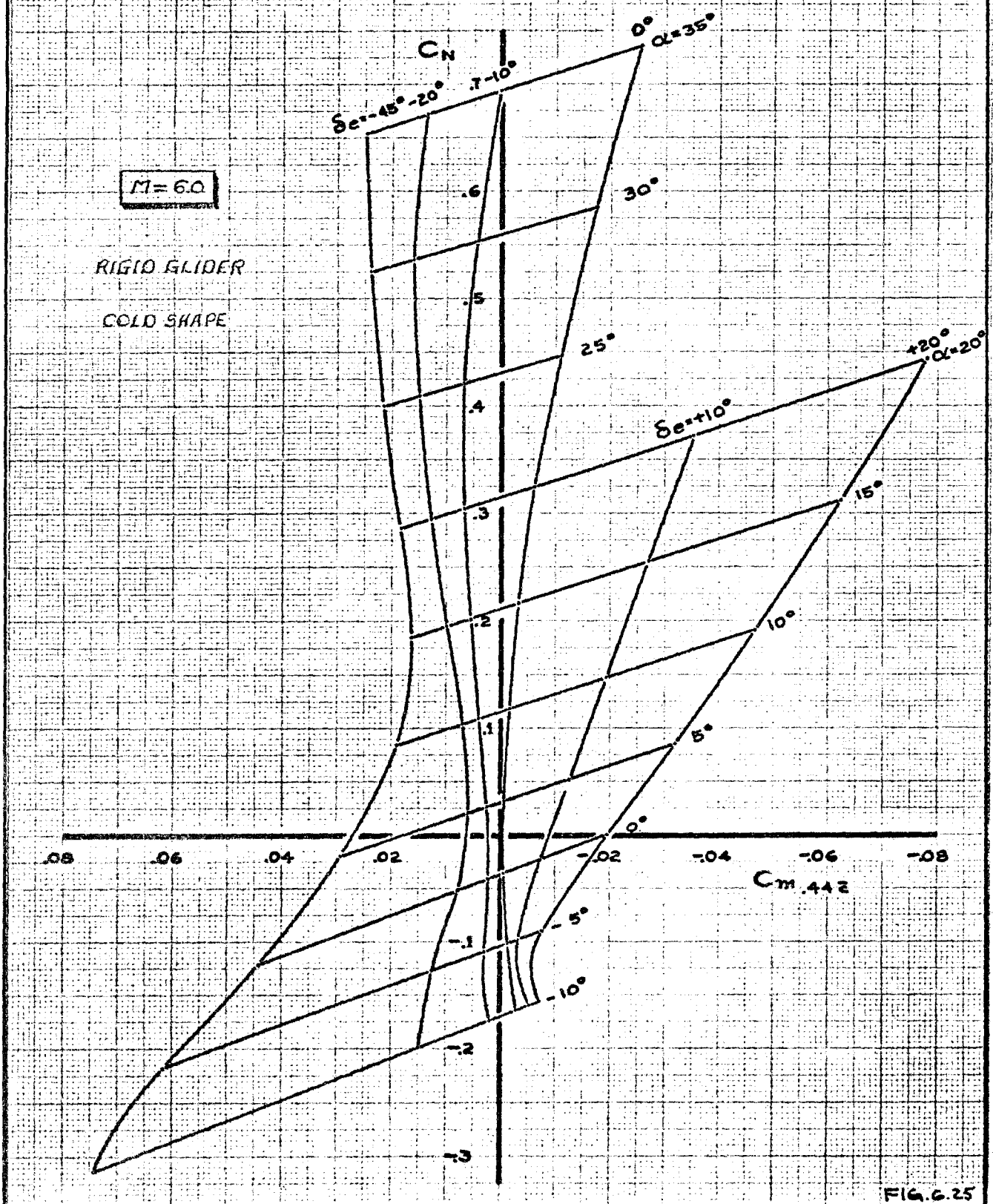


FIG. 6.25

CALC	G D K	11-13-61	REVISED	DATE	COLD SHAPE LONGITUDINAL STABILITY M = 6.0	844- 2050D
CHECK						DE-80065
APR						PAGE
APR						6.32
DRN	TH	12-13-61			THE BOEING COMPANY	

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$M = 8.08$

RIGID GLIDER

COLD SHAPE

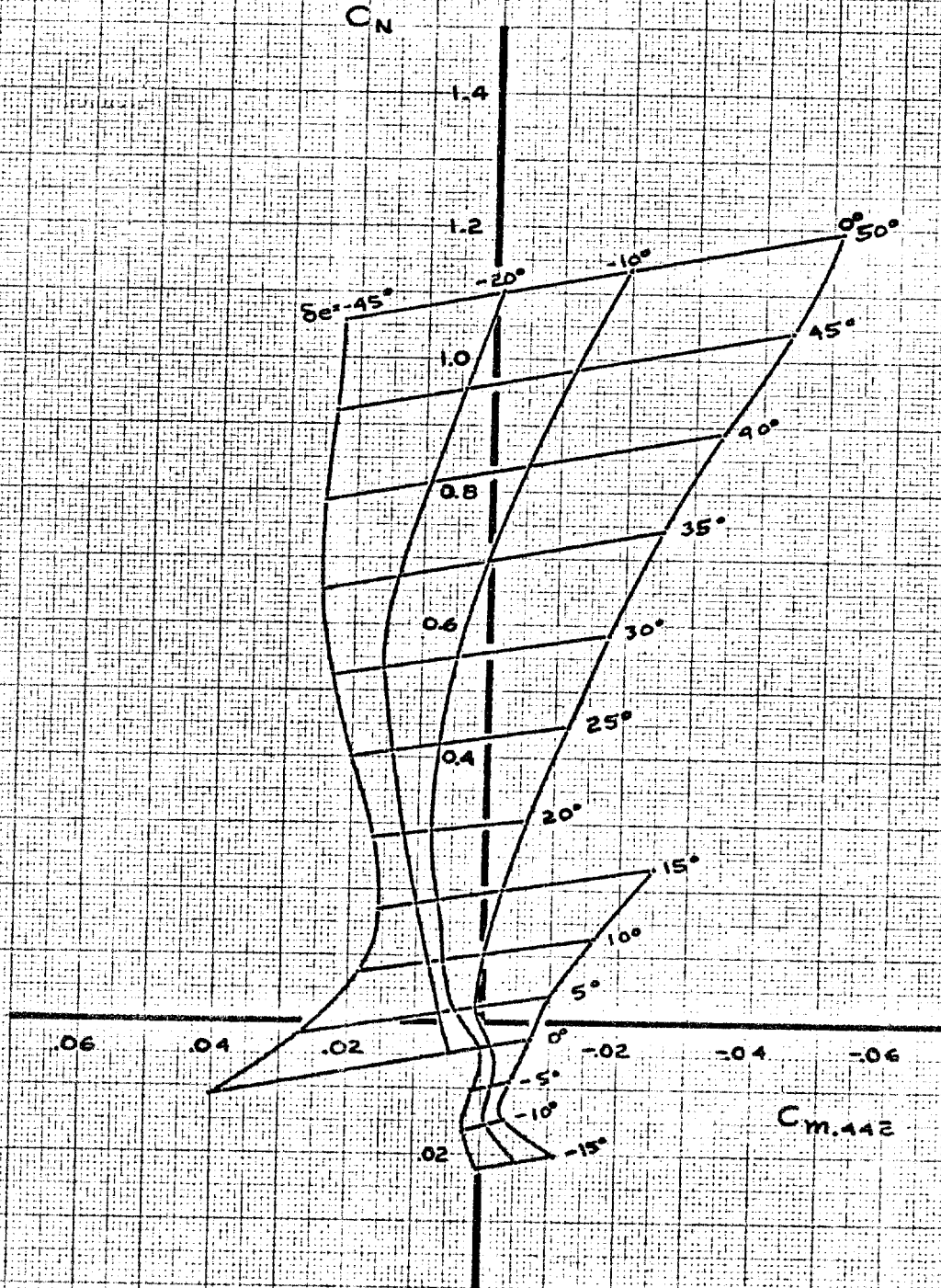


FIG. 6.26

CALC	LDR	REVISED	DATE
CHECK			
APR			
APR			

COLD SHAPE
LONGITUDINAL STABILITY
 $M = 8.08$

THE BOEING COMPANY

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2060.0
02-80065
PAGE
6.33

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$M=9.0$

RIGID FLUIDER

COLD SHAPE

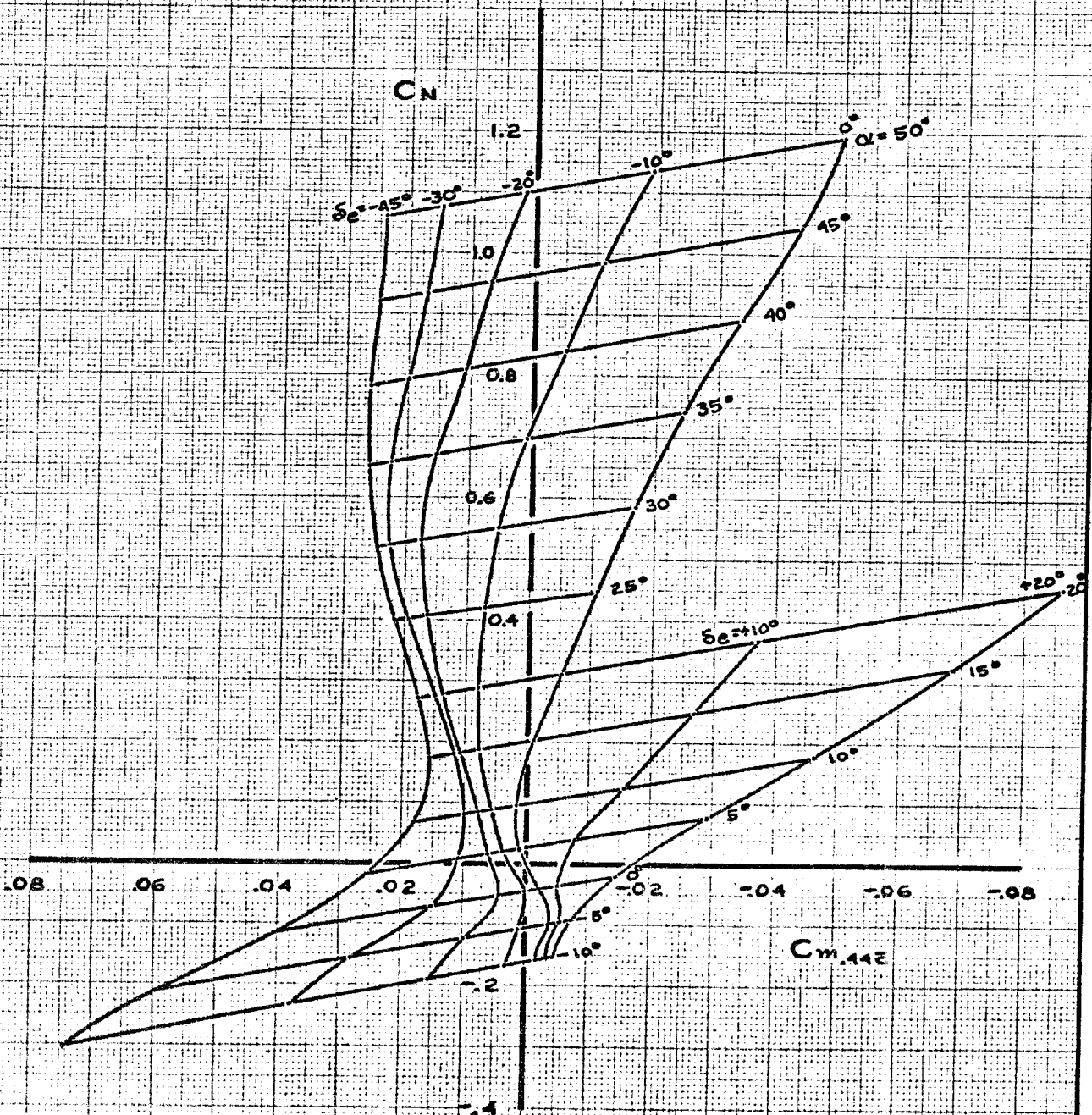


FIG. 6.27

CALC	LDK	12-11-01	REVISED	DATE
CHECK				
APR				
APR				

COLD SHAPE
LONGITUDINAL STABILITY
 $M=9.0$

THE BOEING COMPANY

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20500
D2-80065
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6.34

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250 000 FT-ALT

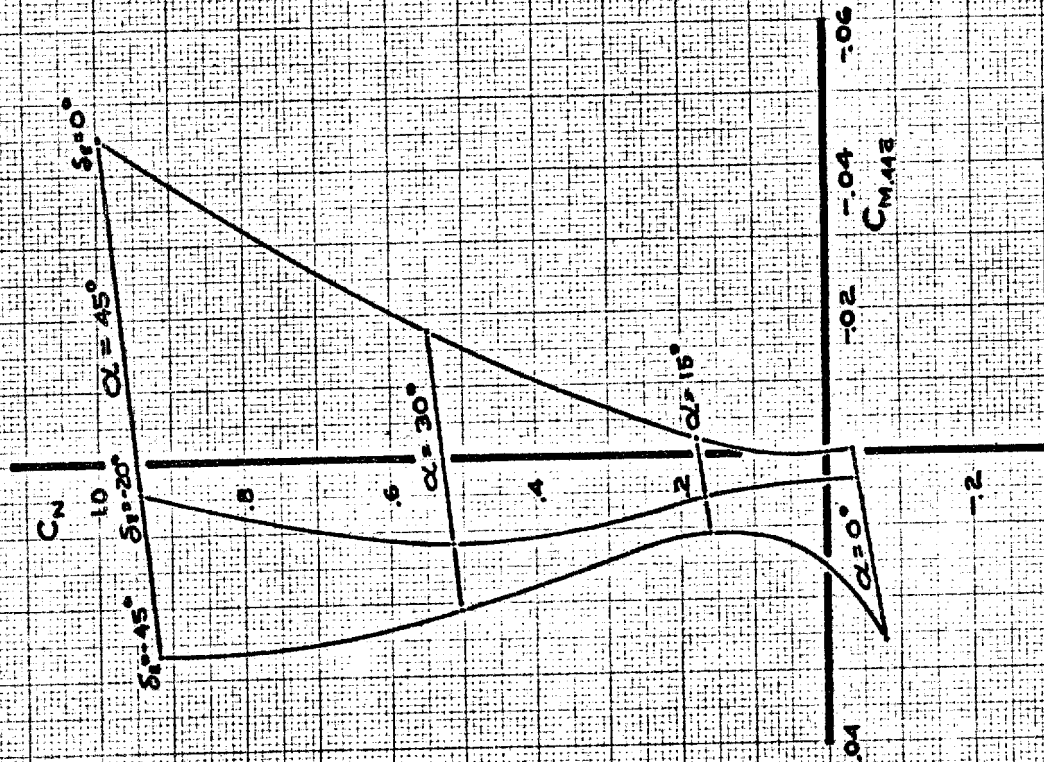


FIG. C. 28

CALC	J.L. FRANCIS	12/14/61	REVISED	DATE
CHECK			12-2-61	
APR				
APR				

COLD SHAPE
LONGITUDINAL STABILITY
250 000 FT ALT

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2050 D
DR-80065
PAGE
6.35

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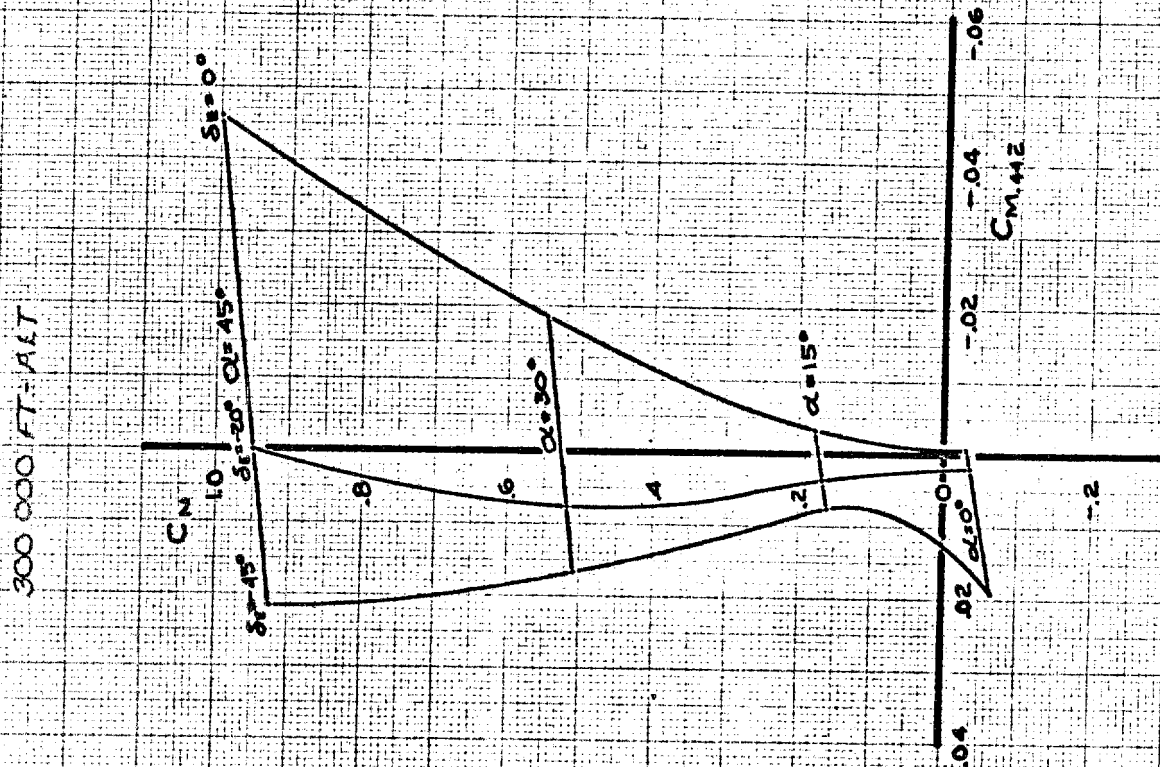


FIG. 6.29

COLD SHAPE
LONGITUDINAL STABILITY
300 000 FT-ALT

THE BOEING COMPANY

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2050 D

DR-80065

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CALC	J.L.F./G.D.K.	12/14/61	REVISED	DATE
CHECK			2/1/61	
APR				
APR				

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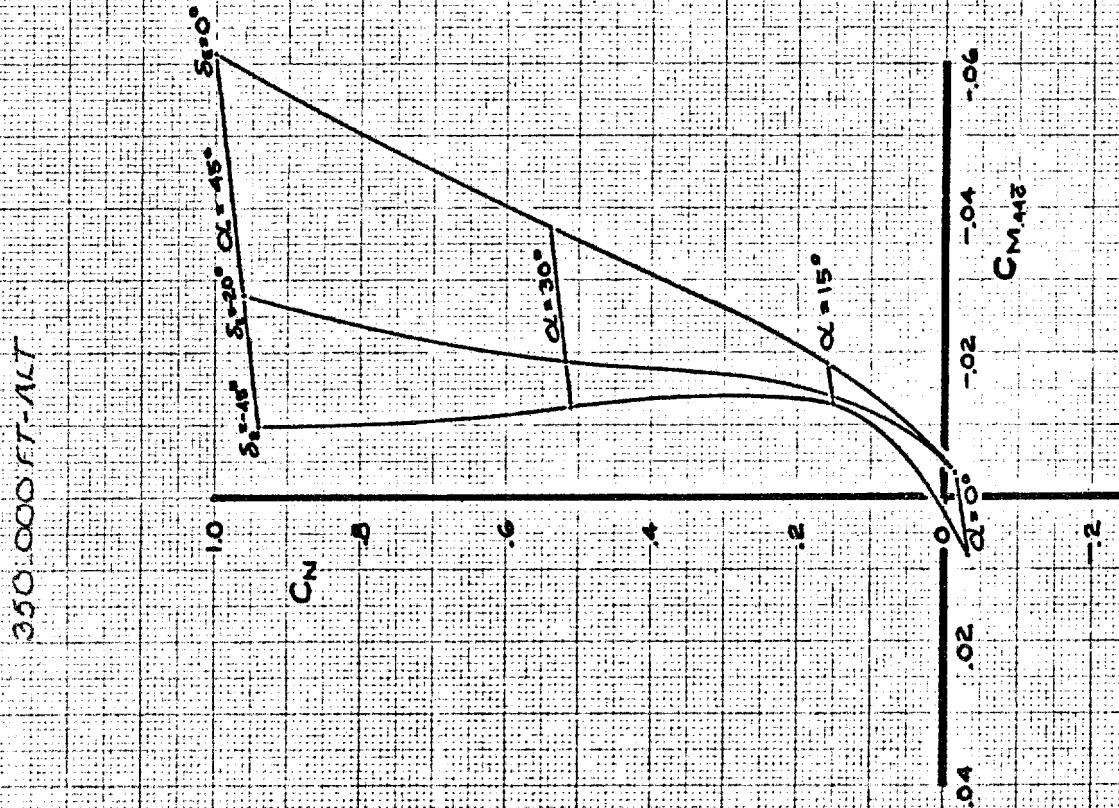


FIG. 6.30

CALC	J.L.F./G.D.K.	12/14/61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

COLD SHAPE
LONGITUDINAL STABILITY
350 000 FT-ALT

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2050 P
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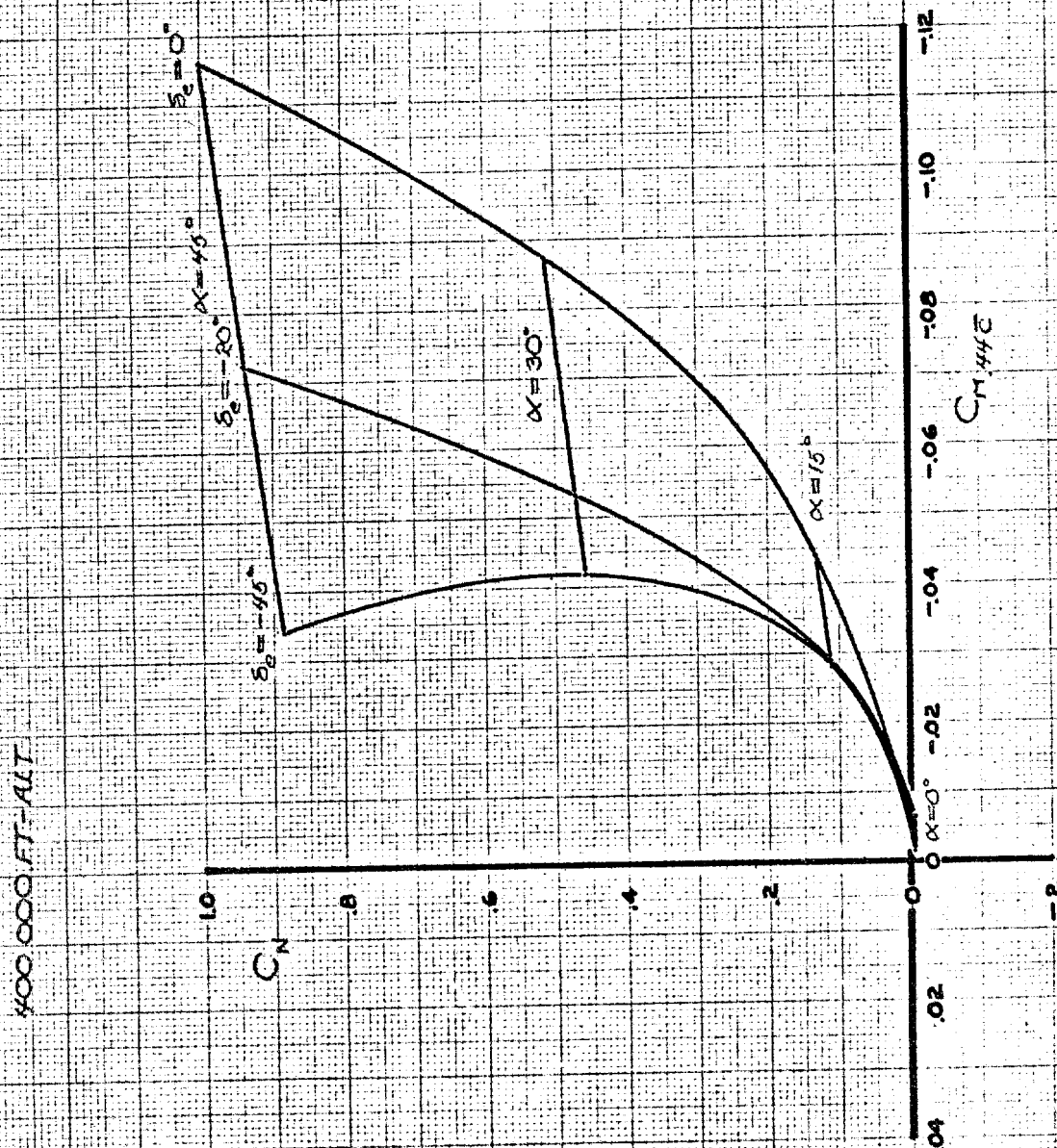


FIG. G.31

CALC	JL FRANCIS	12/14/61	REVISED	DATE
CHECK				
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APR				

COLD SHAPE
LONGITUDINAL STABILITY
400 000 FT-ALT

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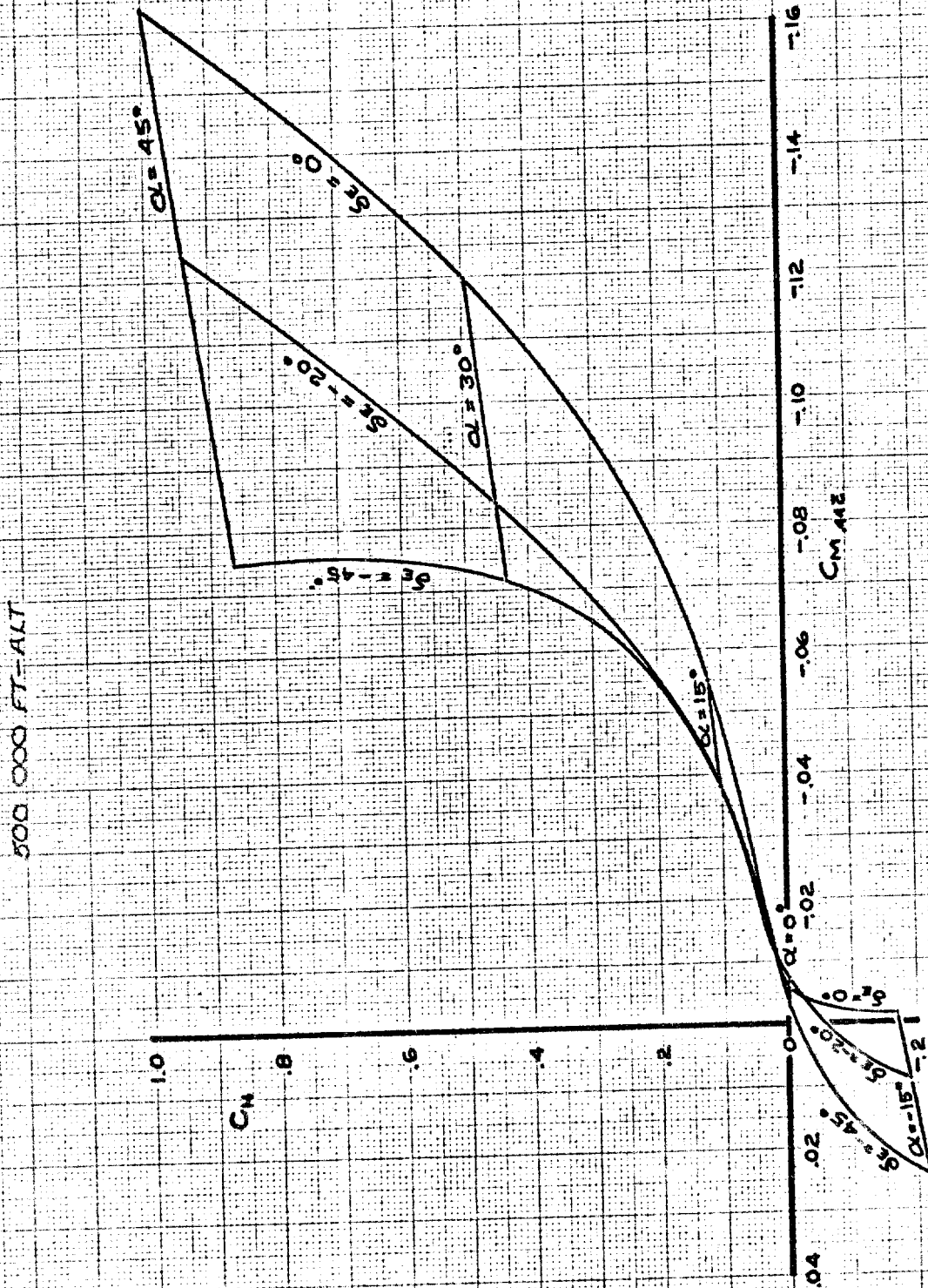


FIG. 6.32

CALC	J.L. Francis	10/3/61	REVISED	DATE
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APR				

COLD SHAPE
LONGITUDINAL STABILITY
500 000 FT-ALT

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$M = 6.0$

RIGID GLIDER
HOT SHAPE

$R_{N2} = 8.1 \times 10^6$
ALTITUDE $\approx 165,000$ FT

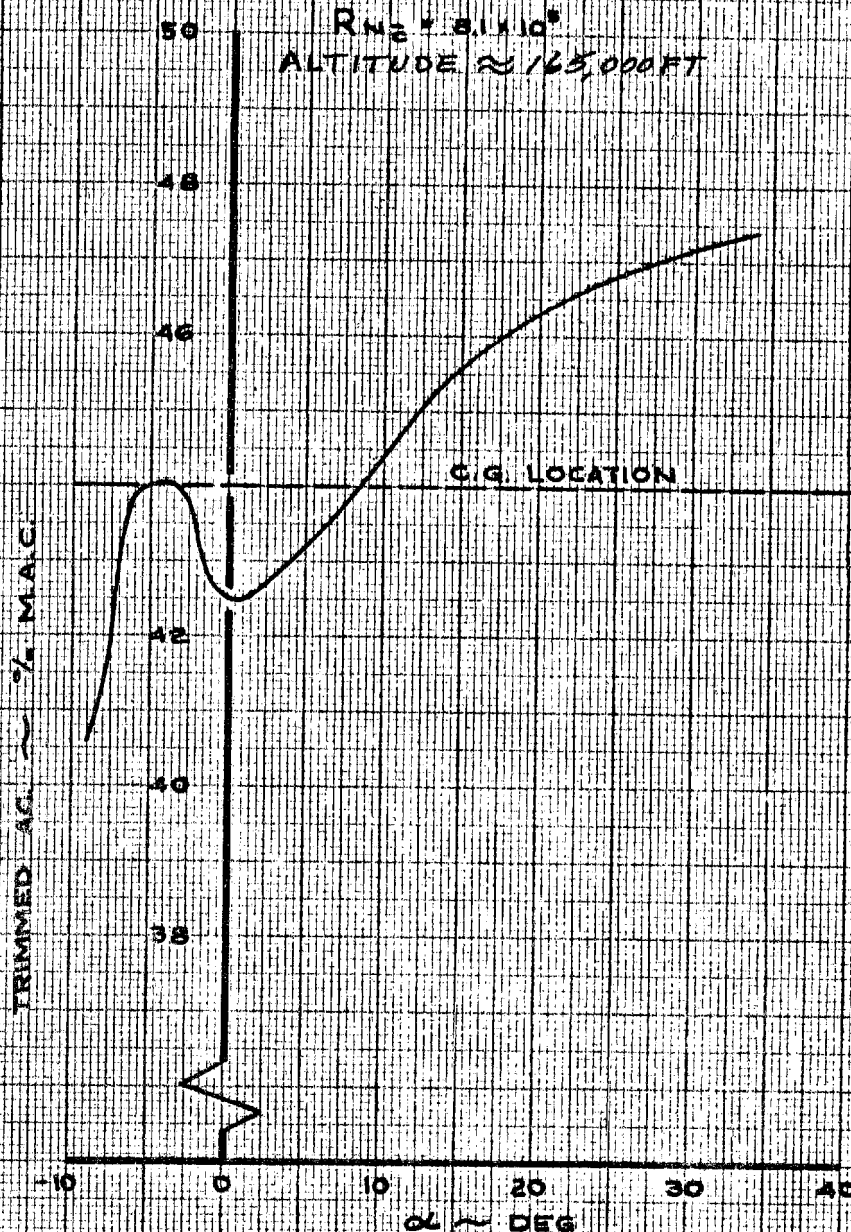


Fig. 6.33

CALC	J.L. FRANCIS	11-10-61	REVISED	DATE	TRIMMED LONGITUDINAL AERODYNAMIC CENTER $M = 6.0$	844 -
CHECK			12-20-61			2050 D
APR						02-80066
APR						
TRACE	N.D.	11-10-61	Approved For Release 2003/10/15 : CIA-RDP70B00584R000200010001-1			
					THE BOEING COMPANY	PAGE

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$M=8.08$

RIGID GLIDER
HOT SHAPE

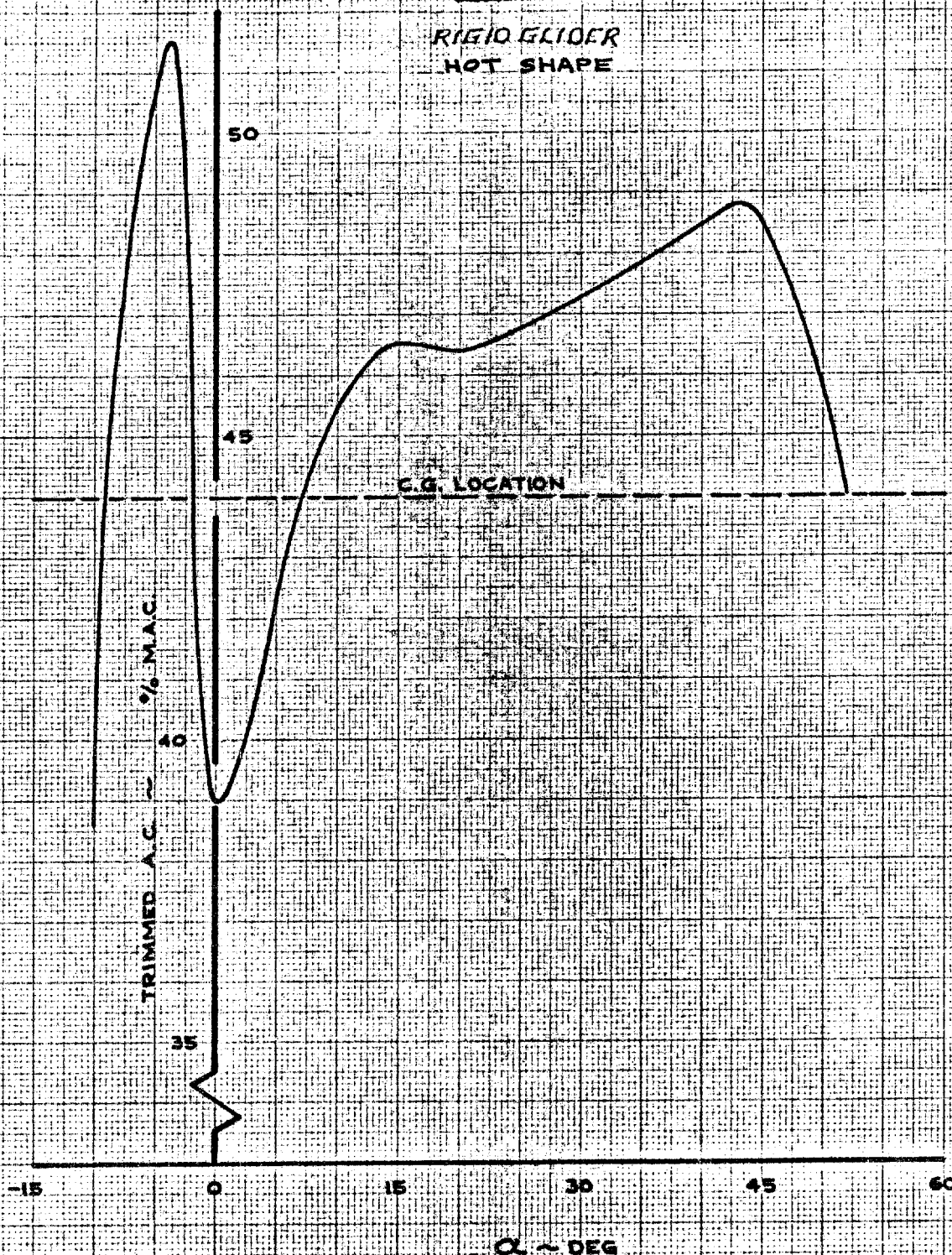


FIG. C.34

CALC	JL. FRANCIS	REVISED	DATE
CHECK		12-20-1	
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APR			
DRM	N.U.	11-2-41	

TRIMMED LONGITUDINAL
AERODYNAMIC CENTER
 $M=8.08$

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$M=9.0$

RIGID GLIDER

HOT SHAPE

$RN_{\bar{z}} = 4.5 \times 10^5$

ALTITUDE $\approx 195,000$ FT

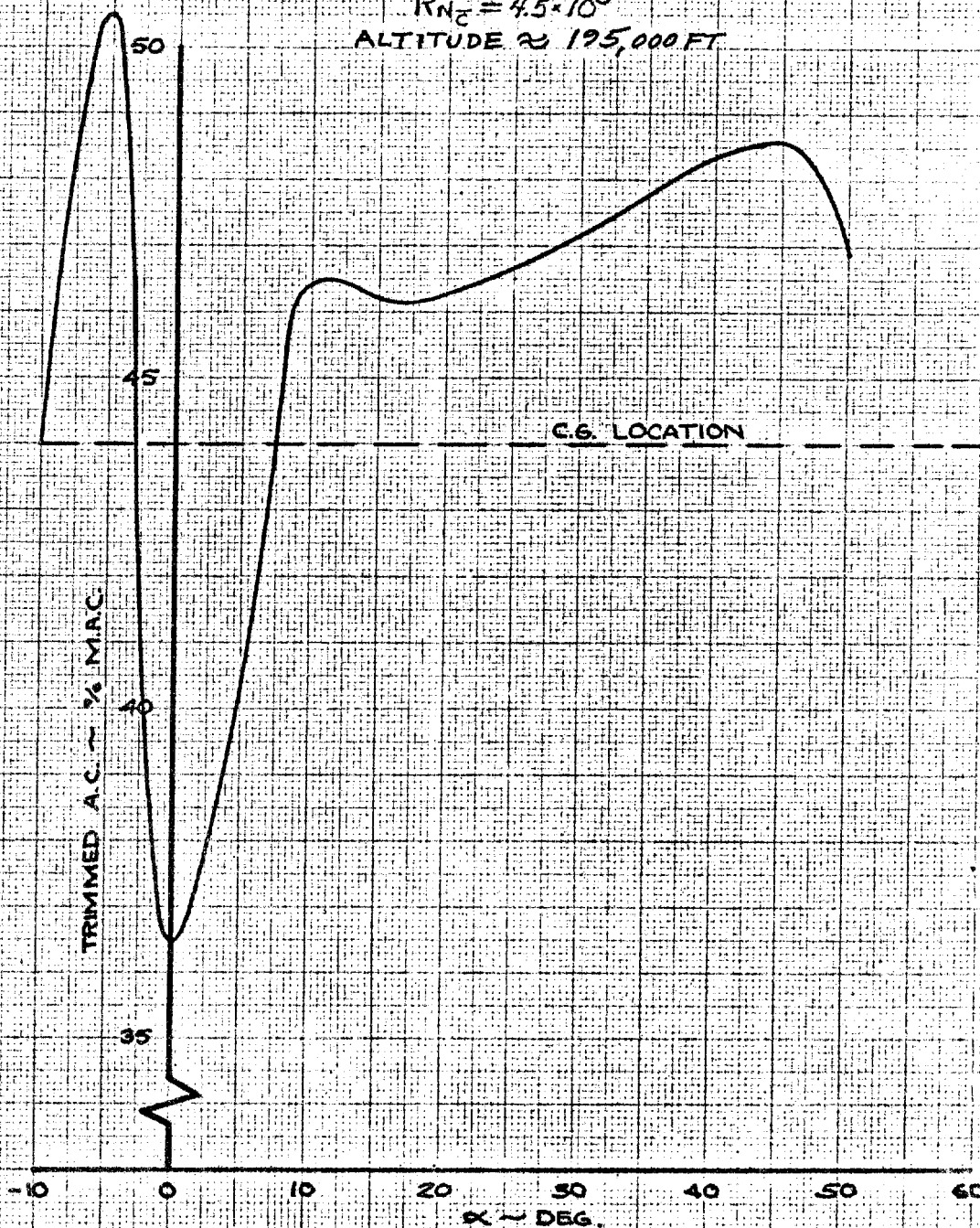


FIG. 6.35

CALC	J.L. FRANCIS	12/13/61	REVISED	DATE
CHECK			12-20-61	
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TRIMMED LONGITUDINAL
AERODYNAMIC CENTER
 $M=9.0$ LOW $RN_{\bar{z}}$

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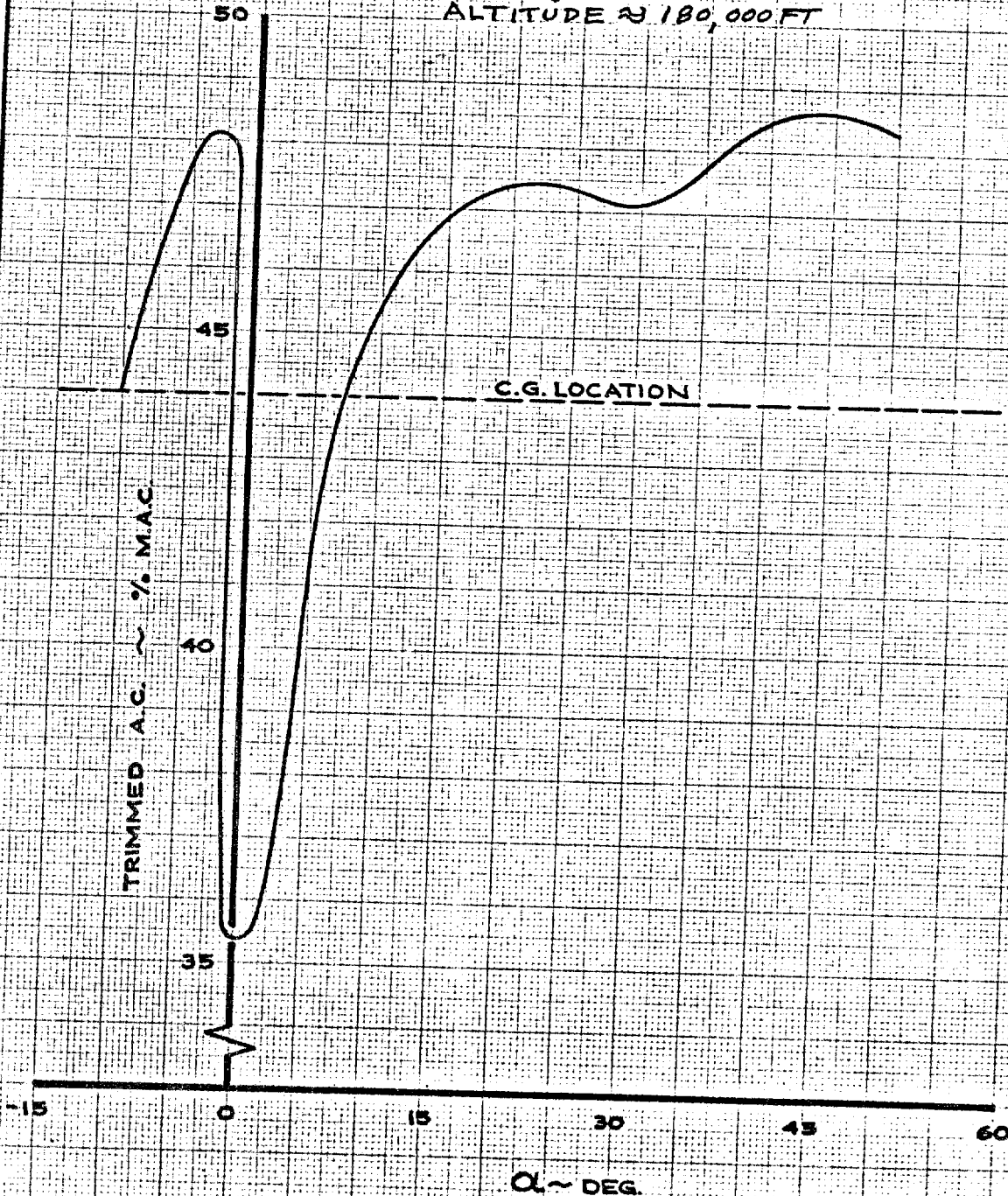
$M = 9.0$

RIGID GLIDER

HOT SHAPE

$R_N = 8.1 \times 10^5$

ALTITUDE $\approx 180,000$ FT



CALC	Emp	11/14/61	REVISED	DATE
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APR				
TRACE	N.U.	11-17-61		

$M = 9.0$
TRIMMED LONGITUDINAL
AERODYNAMIC CENTER

FIG. G.36

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$M=11.0$

RIGID BENDER

HOT SHAPE

$R_{NE} = 4.5 \times 10^5$

ALTITUDE $\approx 195,000$ FT.

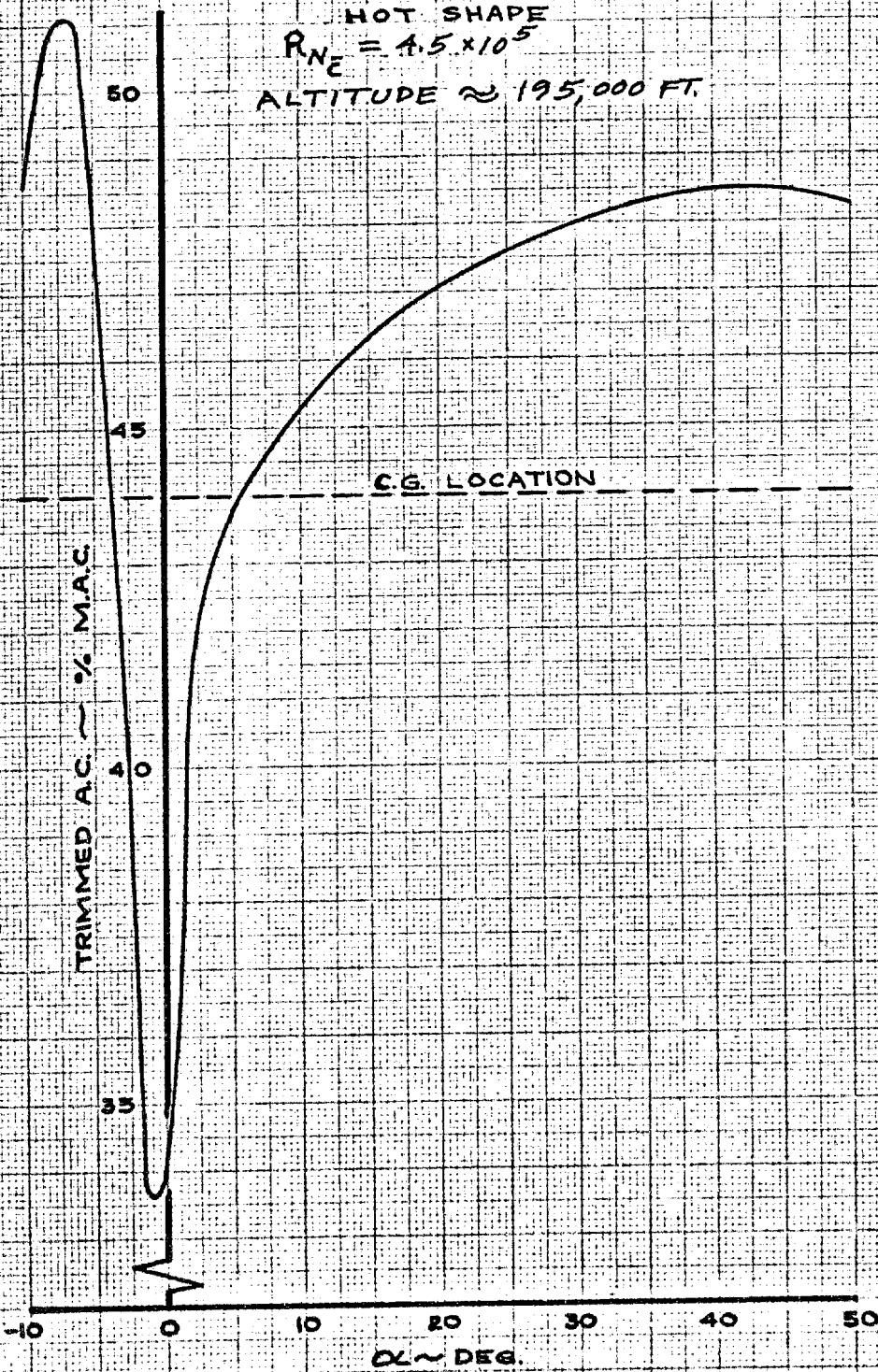


FIG. 6.31

CALC	J.L. FRANCIS	11/14/61	REVISED	DATE	TRIMMED LONGITUDINAL AERODYNAMIC CENTER $M=11.0$	844- 20500
CHECK			12/20-1			02-80065
APR						PAGE
APR						6.44
					THE BOEING COMPANY	

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M = 16

RIGID GLIDER

HOT SHAPE

$R_{NE} = .164 \times 10^6$

ALTITUDE $\approx 236,000$ FT.

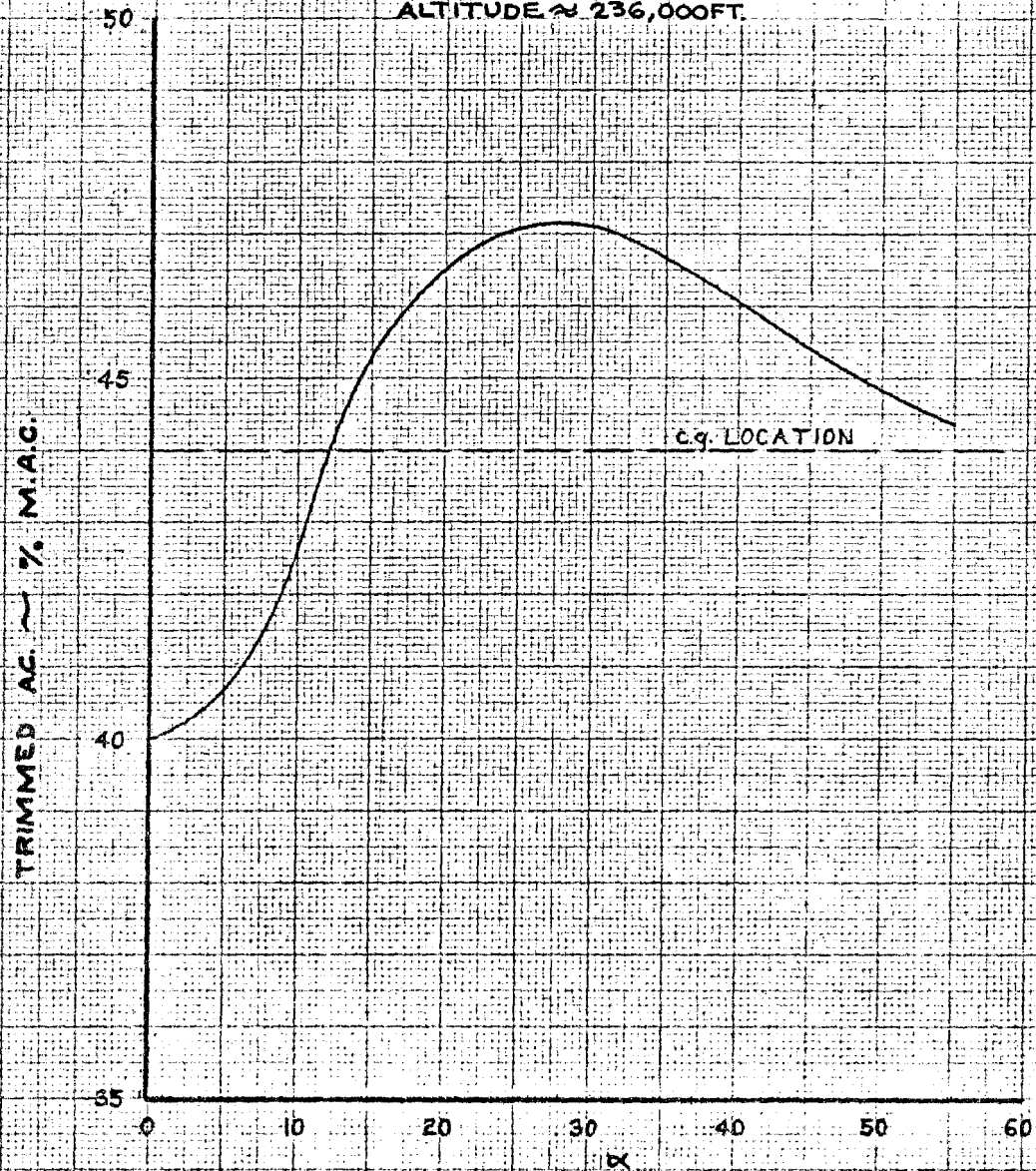


FIG. 6.38

CALC	E.M.P.		REVISED	DATE
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APR				

TRIMMED LONGITUDINAL
AERODYNAMIC CENTER
M = 16

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M=22

RIGID GLIDER

HOT SHAPE

$R_N = .066 \times 10^6$

ALTITUDE $\approx 263,000$ FT.

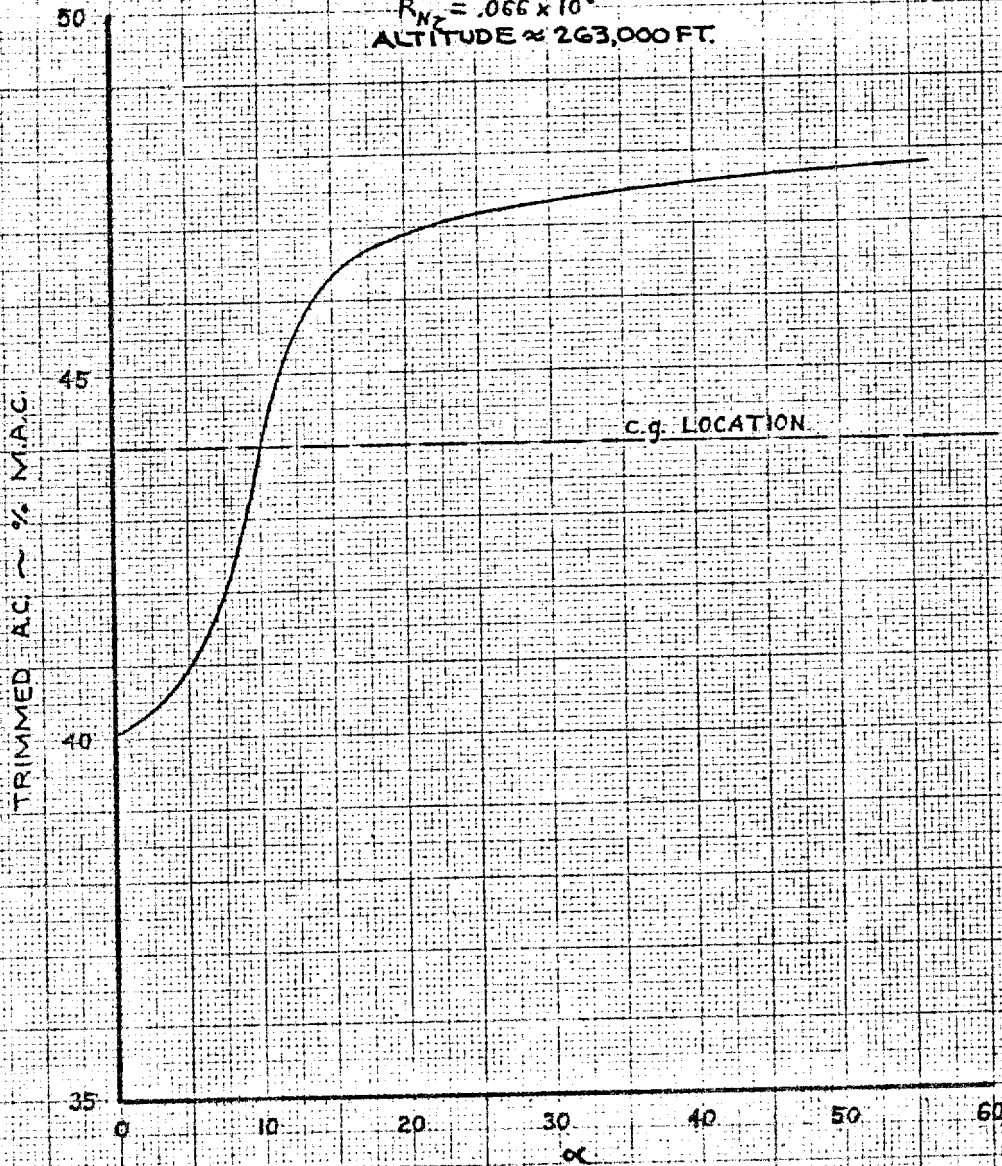


FIG. 6.39

CALC	E.M.P.	REVISED	DATE
CHECK		12-20-61	
APR			
APR			

TRIMMED LONGITUDINAL
AERODYNAMIC CENTER
M = 22

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M = 6.0

**RIGID GLIDER
HOT SHAPE**

$RN_{\xi} = 8.1 \times 10^5$
ALTITUDE $\approx 165,000$ FT

$\delta_{\text{TRIM}} \sim \text{DEG}$

$\alpha \sim \text{DEG}$

FIG. C.40

CALC	J.L. FRANCIS	11-10-61	REVISED	DATE	ELEVON REQUIRED TO TRIM M = 6.0	844- 2050 D
CHECK			12-27-61			02-80065
APR						PAGE
APR						6.47
TRACE	N.D.	11-10-61			THE BOEING COMPANY	

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M = 8.08

**RIGID GLIDER
HOT SHAPE**

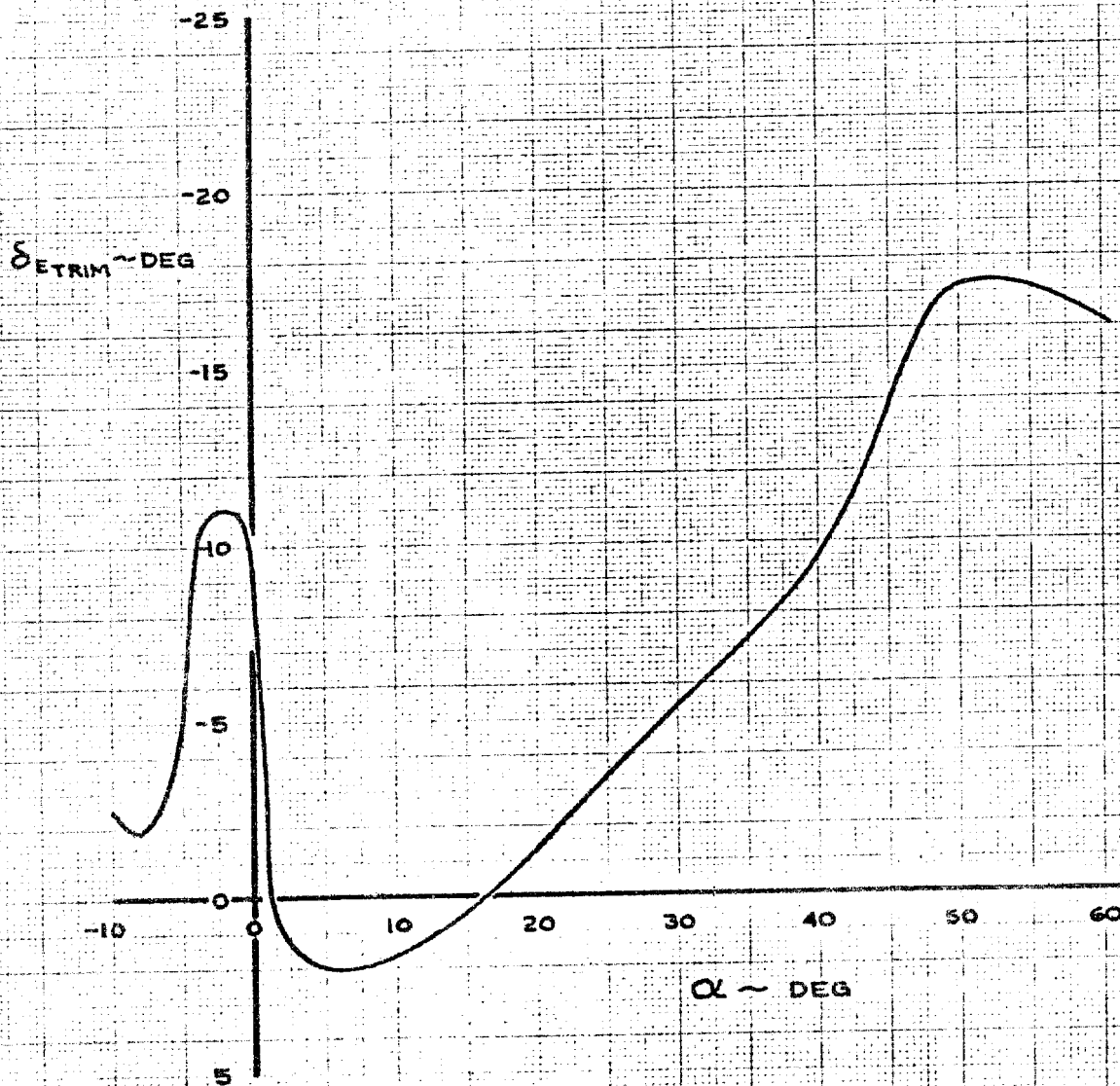


FIG. C.41

CALC	J.L. FRANCIS	11-9-61	REVISED	DATE
CHECK				
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APR				
TRACE	N.U.	11-9-61		

**ELEVON REQUIRED
TO TRIM
M = 8.08**

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$M = 9.0$

RIGID GLIDER

HOT SHAPE

$R_{NE} = 4.5 \cdot 10^5$

ALTITUDE $\approx 195,000$ FT

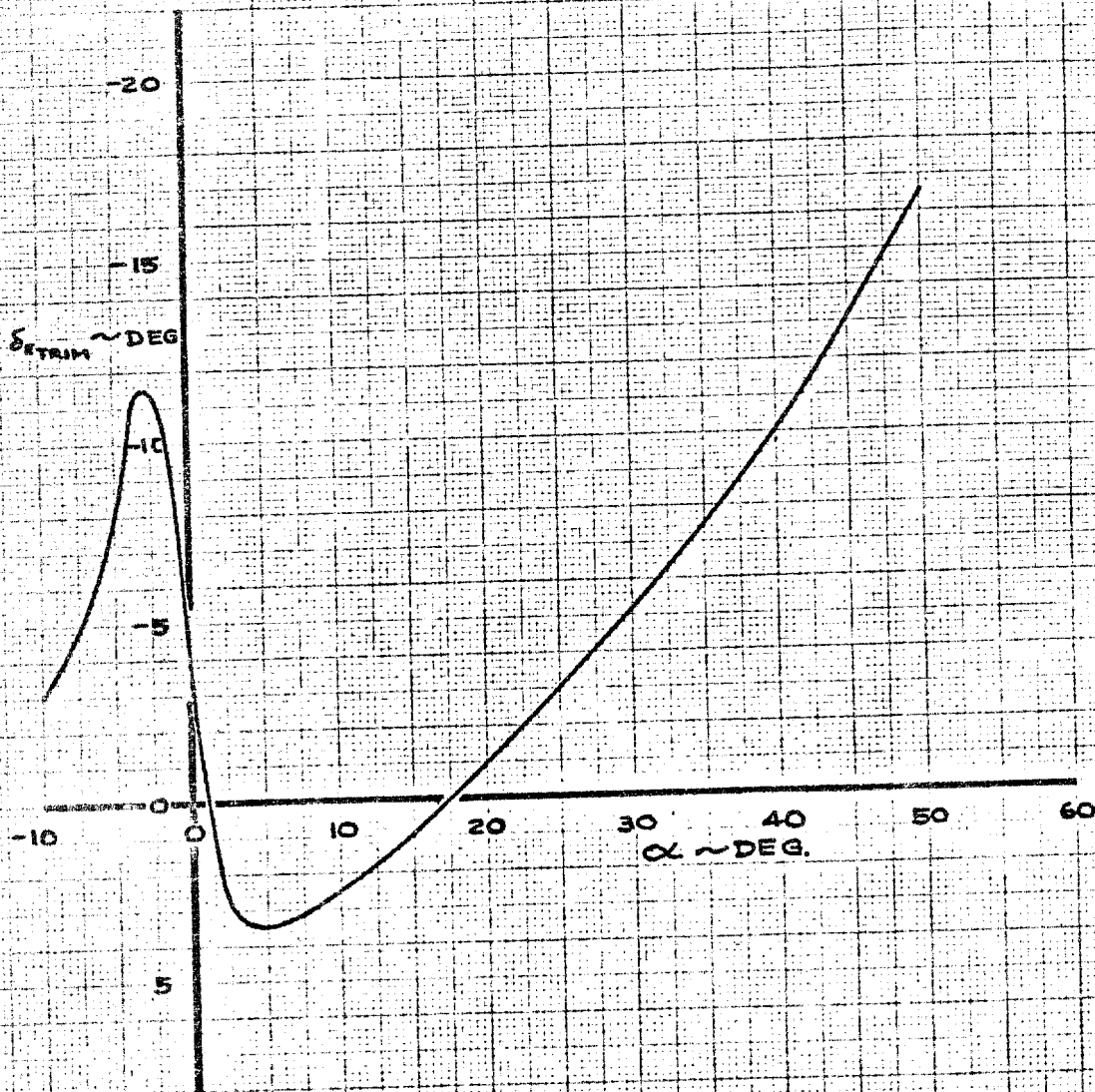


FIG. 6.42

CALC	JL FRANCIS	12-11-1	REVISED	DATE
CHECK			12-2-7	
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ELEVON REQUIRED
TO TRIM
 $M = 9.0$ LOW R_{NE}

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$M = 9.0$

RIGID GLIDER

HOT SHAPE

$R_{N\bar{c}} = 5.1 \times 10^5$

ALTITUDE $\approx 180,000$ FT

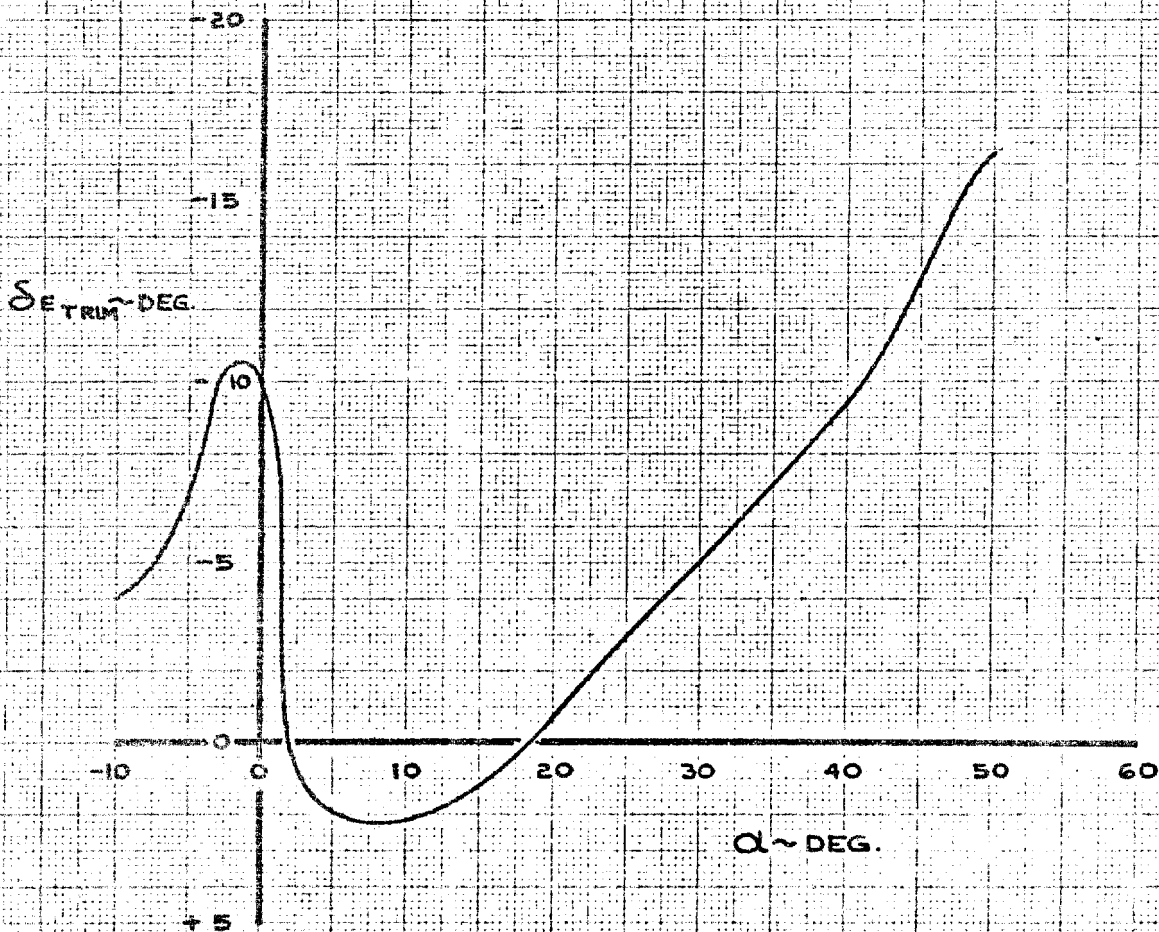


FIG. 6.43

CALC	J.L. FRANCIS	11-10-61	REVISED	DATE
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APR				
DRM	MIL	11-10-61		

ELEVON REQUIRED
TO TRIM
 $M = 9.0$

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$M=11.0$

RIGID GLIDER
HOT SHAPE
 $R_{N_2} = 4.5 \times 10^5$
ALTITUDE $\approx 195,000$ FT.

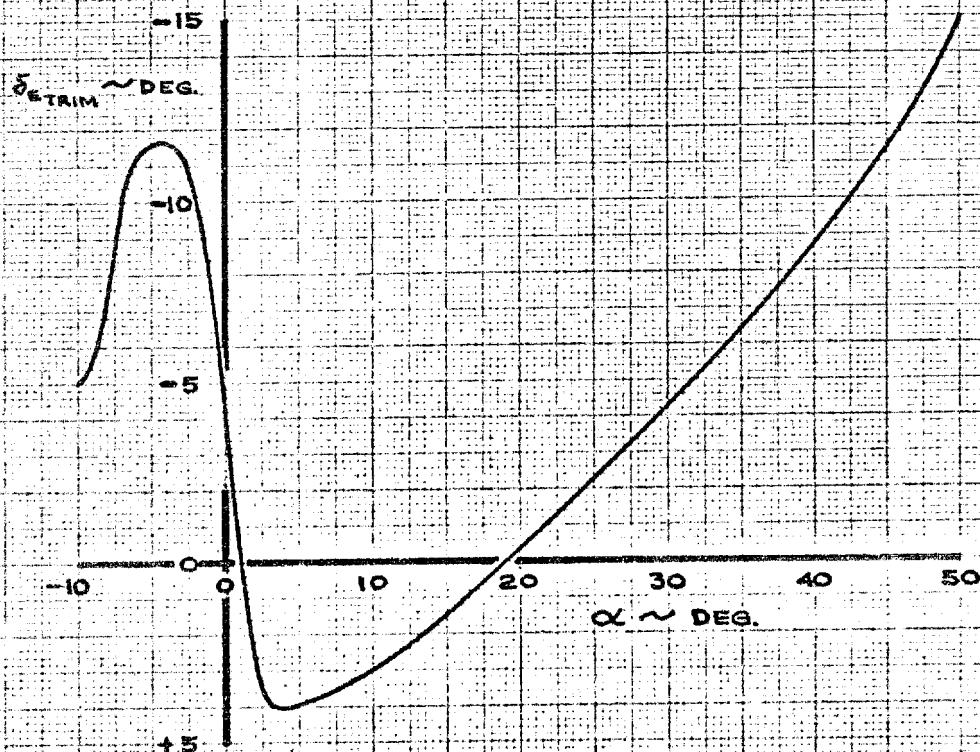


FIG. G.44

CALC	J.L. FRANCIS	11/14/61	REVISED	DATE
CHECK			12/2/61	
APR				
APR				

ELEVON REQUIRED
TO TRIM
 $M=11.0$

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$M=16.0$

RIGID GLIDER

HOT SHAPE

$R_{N2} = .164 \times 10^6$

ALTITUDE $\approx 236,000$ FT.

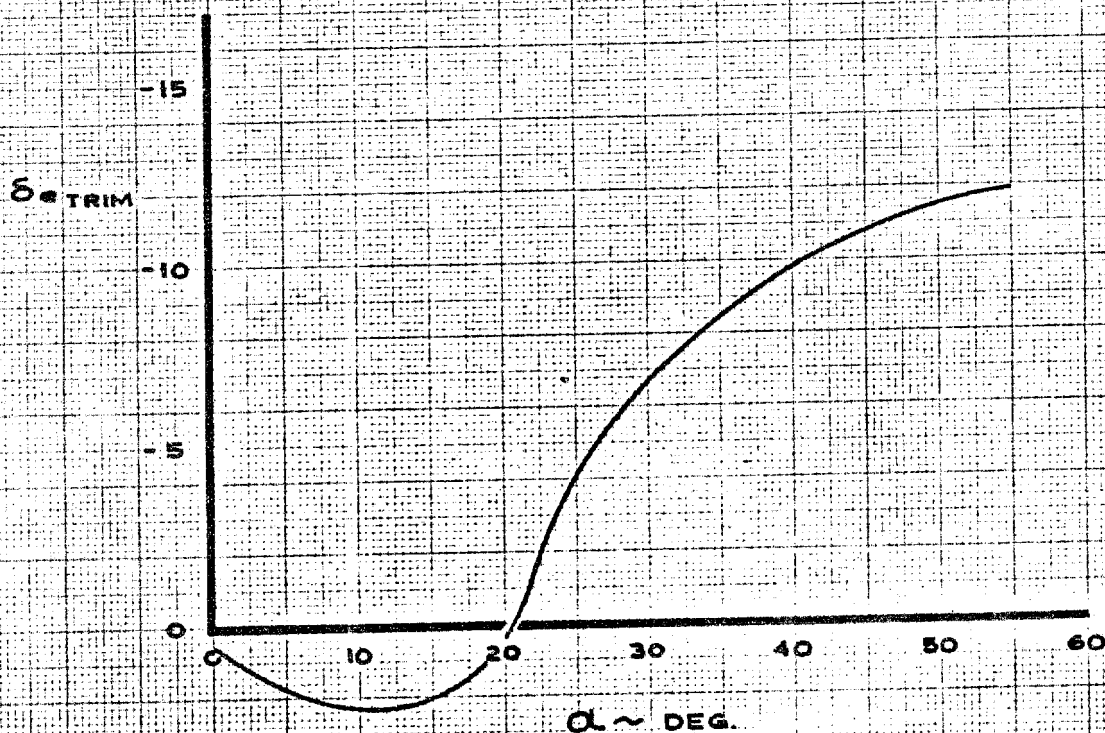


FIG. 6.45

CALC	Emp	11/10/61	REVISED	DATE
CHECK			2-22-61	
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APR				
TRACE	11/17/61			

ELEVON REQUIRED TO TRIM
 $M=16.0$

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$M=22$

RIGID GLIDER

HOT SHAPE

$R_{H/C} = .066 \times 10^6$

ALTITUDE \approx 263,000 FT.

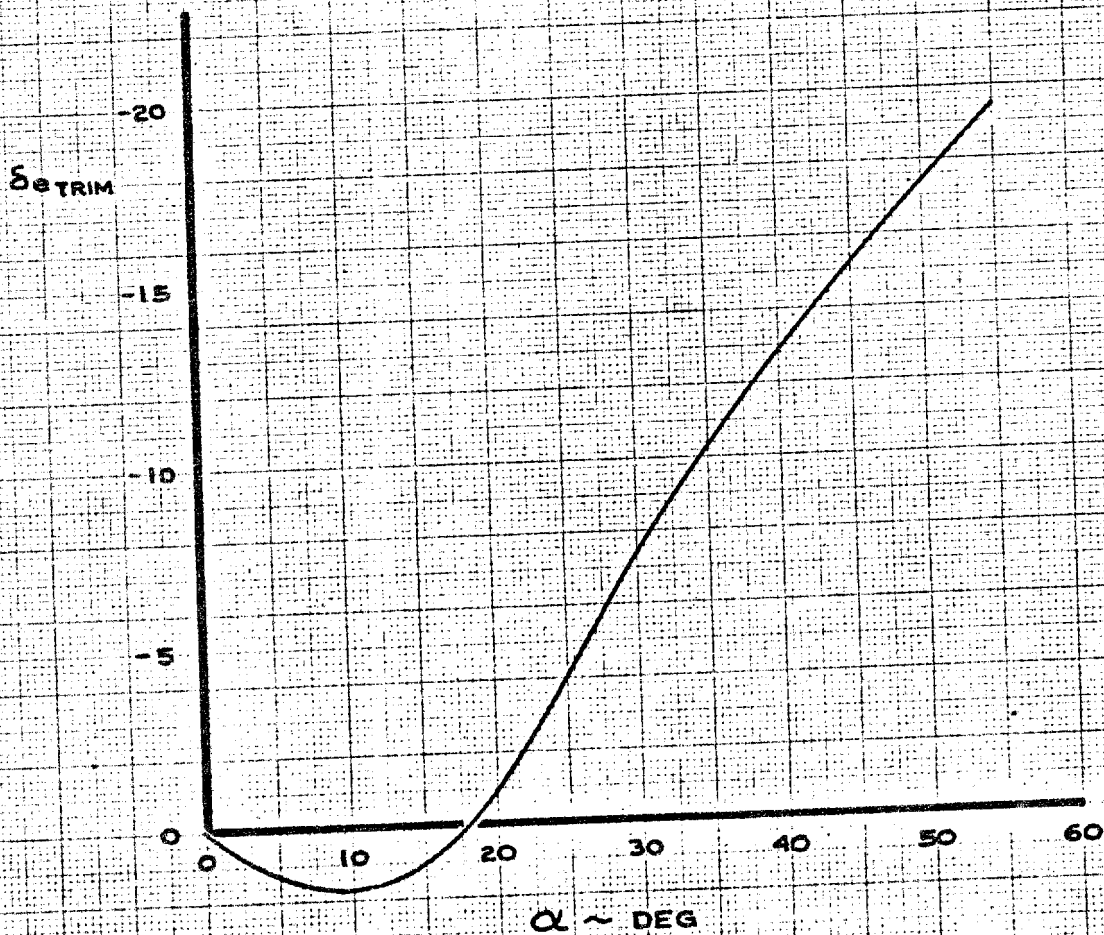


FIG. 6-46

CALC	Emb	11/8/61	REVISED	DATE
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APR				
TRACE	N.A.			

ELEVON REQUIRED TO TRIM

$M=22$

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NOTE: 10° ELEVON DEFLECTION
ABOUT TRIM POSITION

$M = 8.08$

RIGID GLIDER
HOT SHAPE

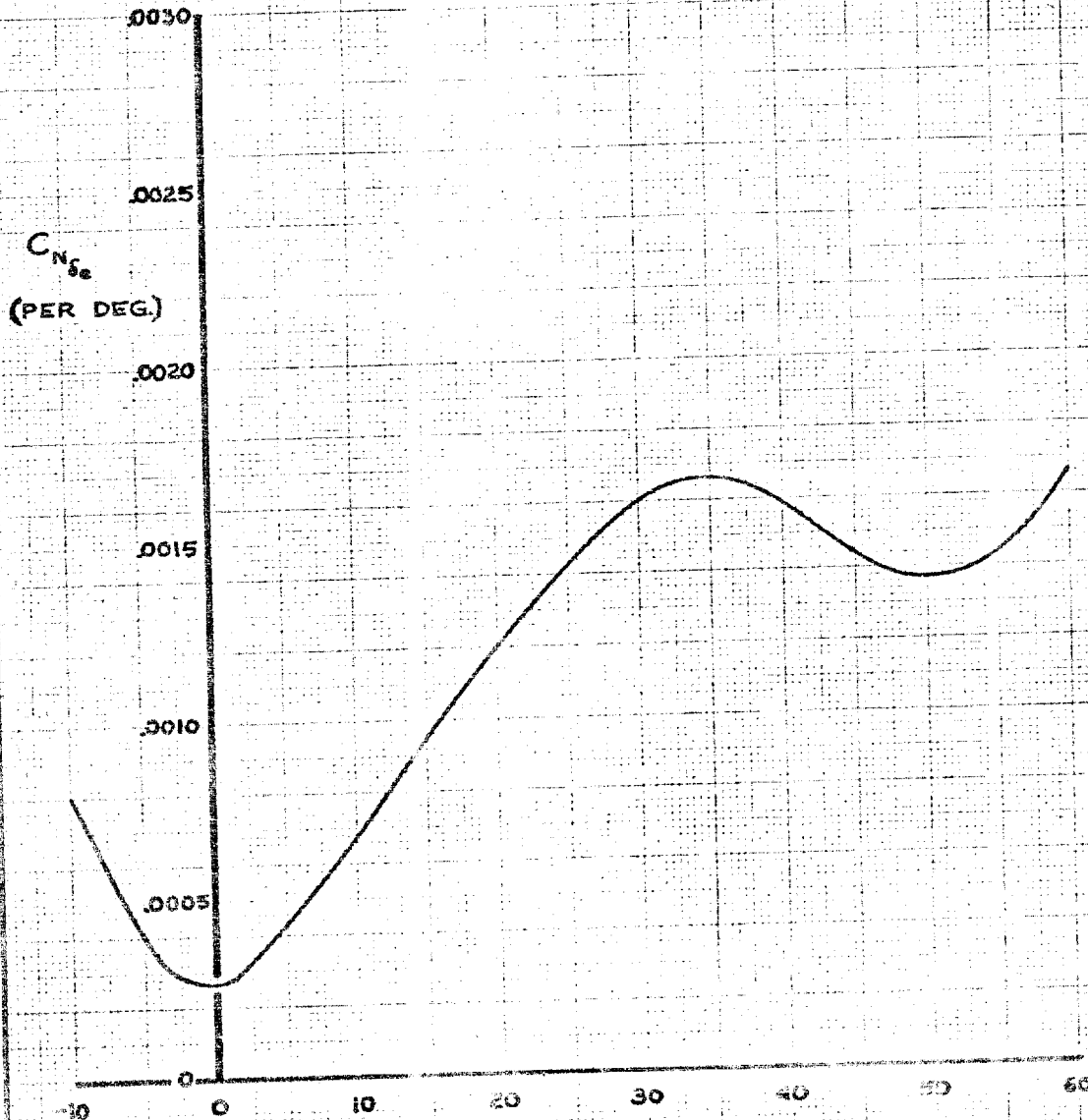


FIG. C.47

CALC	CHK	REVISED	DATE
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APR			

EFFECT OF ELEVON
ON NORMAL FORCE

$M = 8.08$

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$M=22.0$

RIGID SLIDER

HOT SHAPE

$R_{N_2} = 1.066 \times 10^6$

NOTE

CORRESPONDING ALTITUDES
FOR EQUILIBRIUM GLIDE:

1) $C_{L_{MAX}} \sim 263,000$ FT.

2) $(L/D)_{MAX} \sim 266,000$ FT.

$C_{N_{\delta_e}}$
(PER DEG)

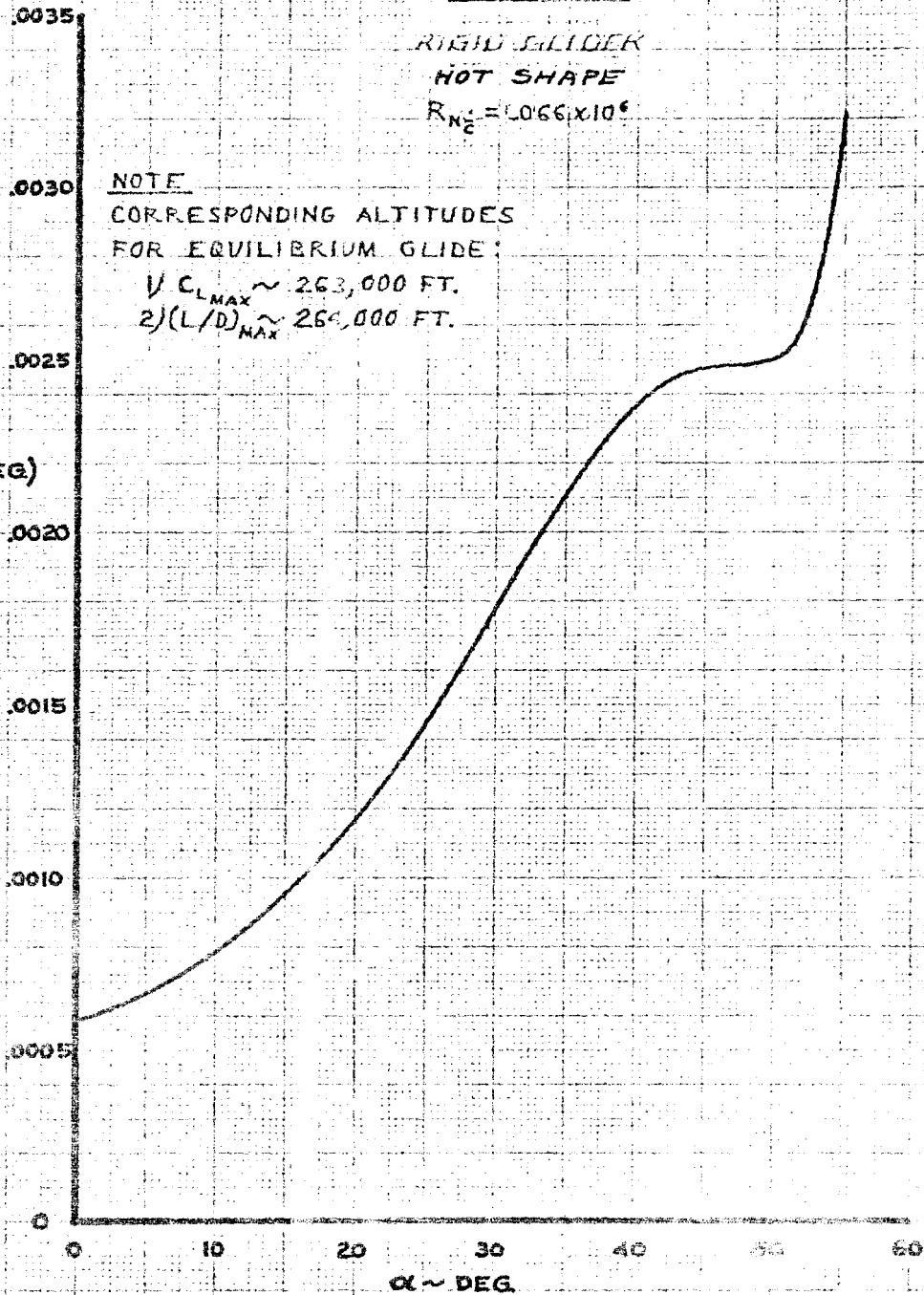


FIG. 6A8

CALC		REVISED	DATE
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APR			

EFFECT OF ELEVON
ON NORMAL FORCE
 $M=22.0$

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$M = 6.0$

NOTE: SLOPES TAKEN
AT TRIM δ_e

RIGID GLIDER
HOT SHAPE
 $RNE = 8.1 \times 10^5$

ALTITUDE $\approx 16,500$ FT.

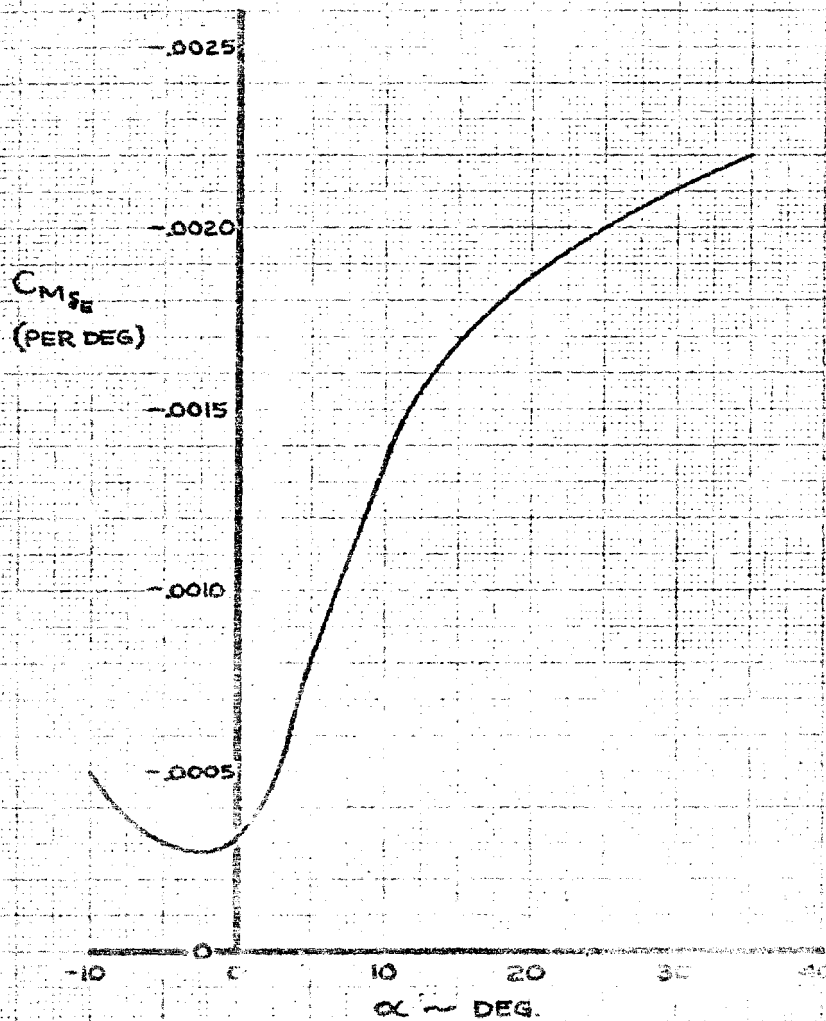


FIG. C.49

CALC	J.L.F.		REVISED	DATE	ELEVON EFFECTIVENESS ABOUT TRIM $M = 6.0$ THE BOEING COMPANY	844-
CHECK						2050 D
APR						D2-89065
APR						PAGE
						6.56

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NOTE: SLOPE TAKEN
AT TRIM δ_e

M=8.0

RIGID GLIDER
HOT SHAPE

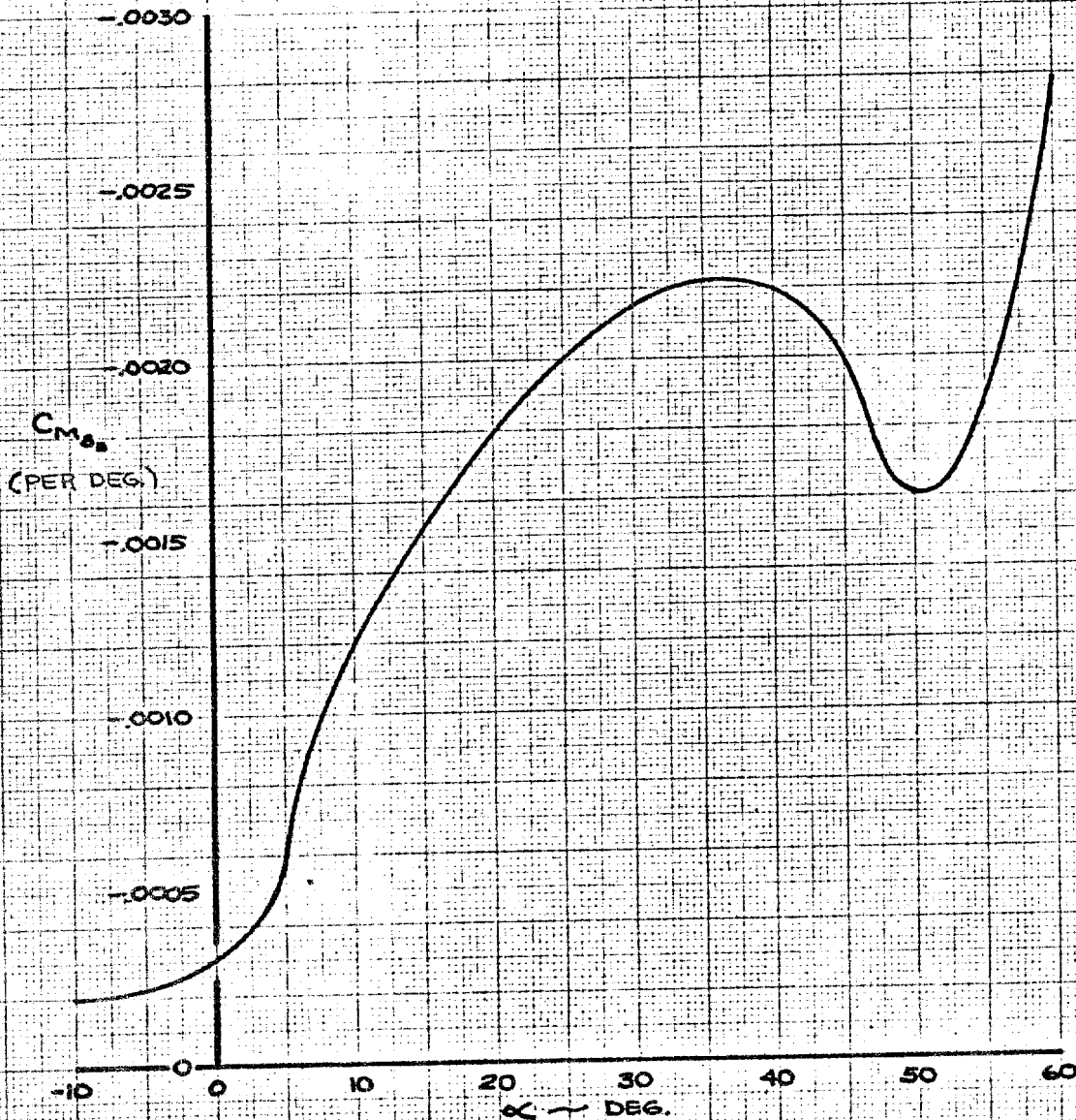


FIG. 6.50

CALC	J.L. FRANCIS	12/15/61	REVISED	DATE
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APR				
APR				

ELEVON EFFECTIVENESS
ABOUT TRIM
M=8.0

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M=9.0

NOTE: SLOPE TAKEN
AT TRIM δ

RIGID GLIDER
HOT SHAPE
 $R_{N2} = 4.5 \times 10^5$
ALTITUDE $\approx 195,000$ FT.

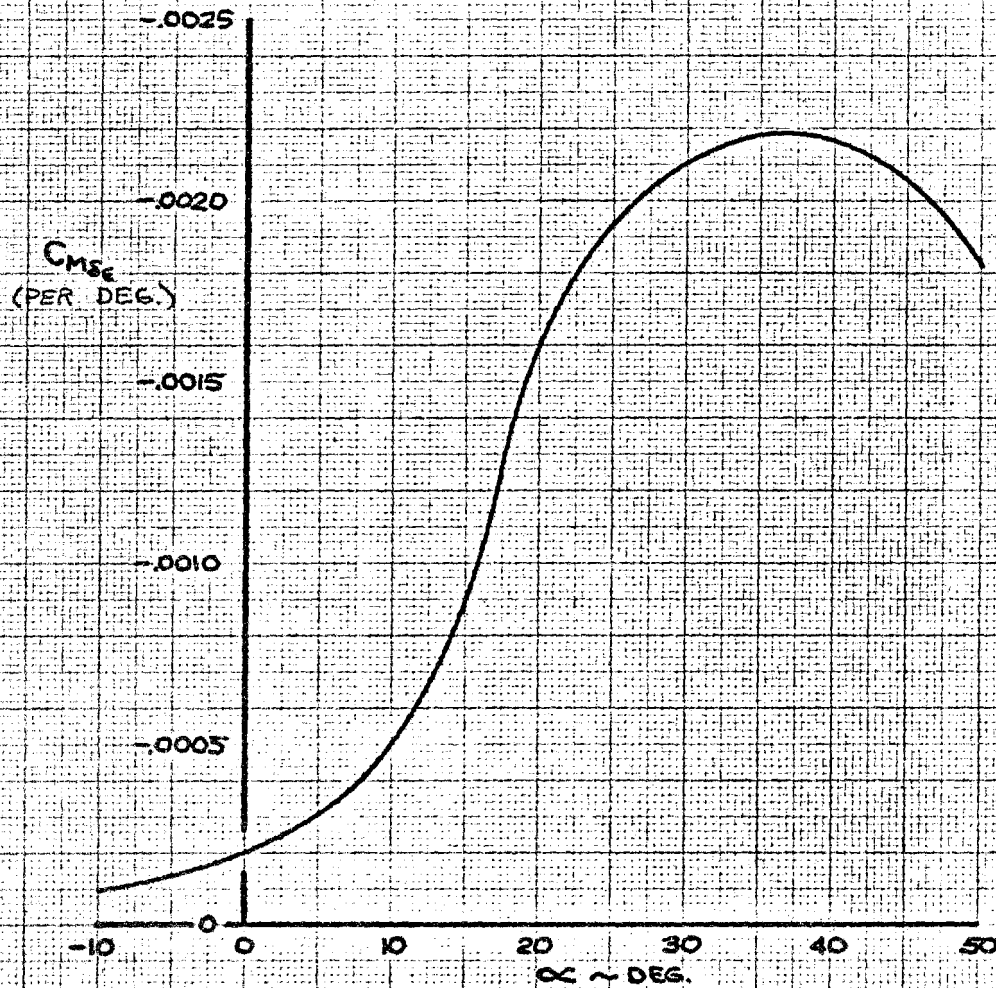


FIG. 6.51

CALC	J.L. FRANCIS	12/13/61	REVISED	DATE
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ELEVON EFFECTIVENESS
ABOUT TRIM
M=9.0 - LOW R_{N2}

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M = 9.0

NOTE: SLOPE TAKEN
AT TRIM δ_c

RIGID GLIDER
HOT SHAPE
 $RN_E = 8.1 \times 10^5$
ALTITUDE $\approx 189,000$ FT

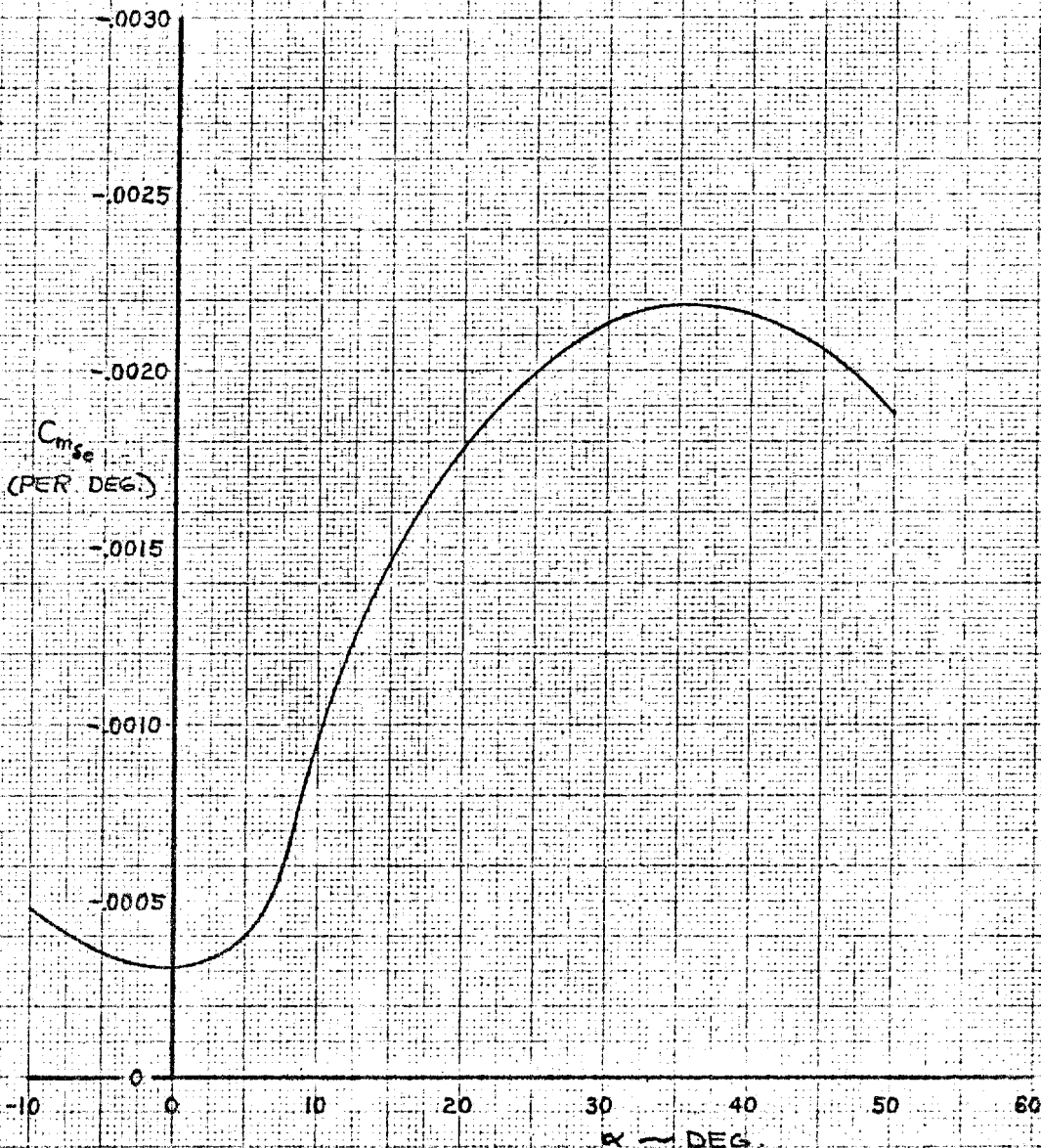


FIG. C.52

CALC	E.M.P.		REVISED	DATE
CHECK			12-2-51	
APR				
APR				

ELEVON EFFECTIVENESS
ABOUT TRIM
M = 9.0

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$M=11$

NOTE: SLOPES TAKEN
AT TRIM δ_e

RIGID GLIDER
NOT SHAPE
 $R_{N2} = 4.5 \times 10^{-5}$
ALTITUDE $\approx 195,000$ FT

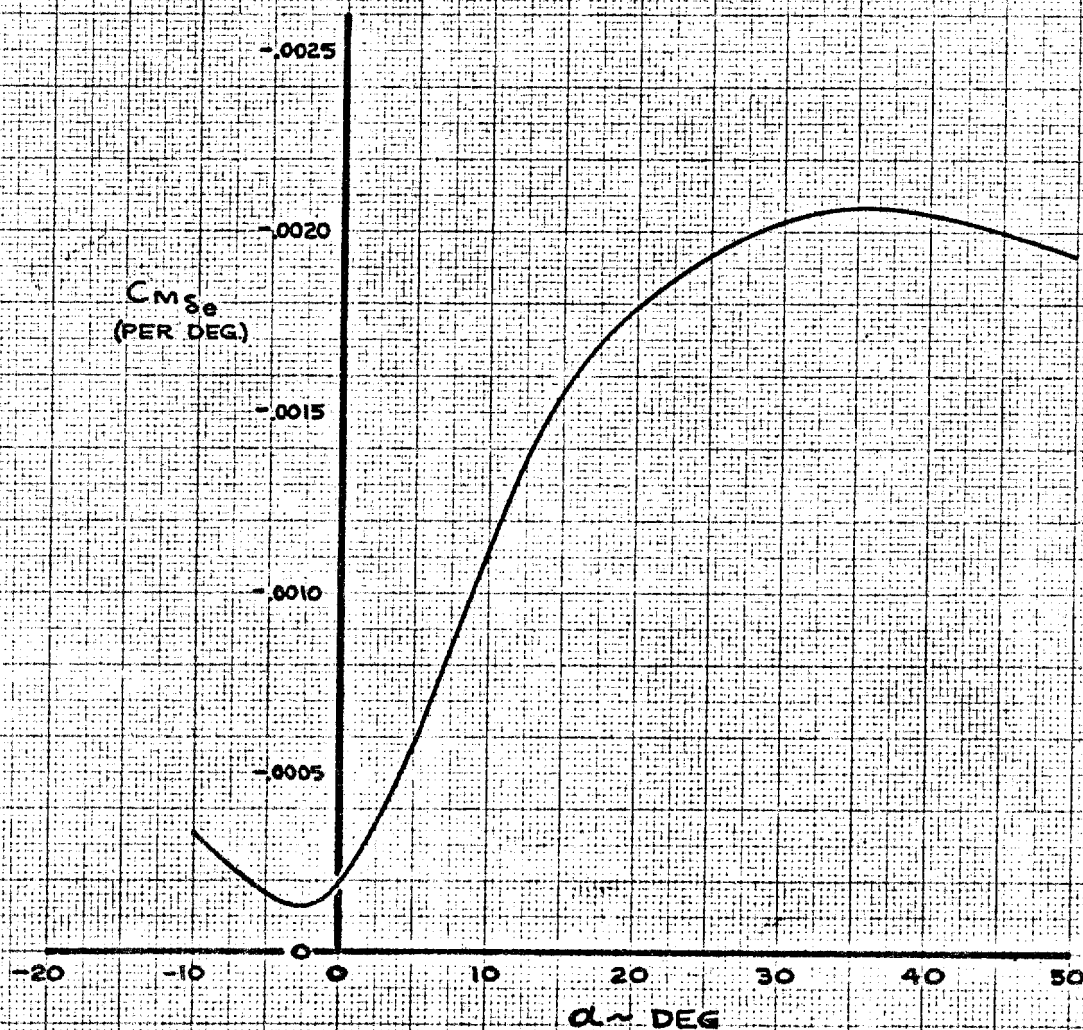


Fig. 6.53

CALC	EMIP	REVISED	DATE
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APR			
PLOT	NU		

ELEVON EFFECTIVENESS
ABOUT TRIM
 $M=11$

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NOTE: SLOPES TAKEN
AT TRIM δ_e

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$M=16$

RIGID GLIDER

HOT SHAPE

$R_{NE} = .164 \times 10^6$

ALTITUDE $\approx 236,000$ FT.

$C_{m\delta_e}$
(PER DEG)

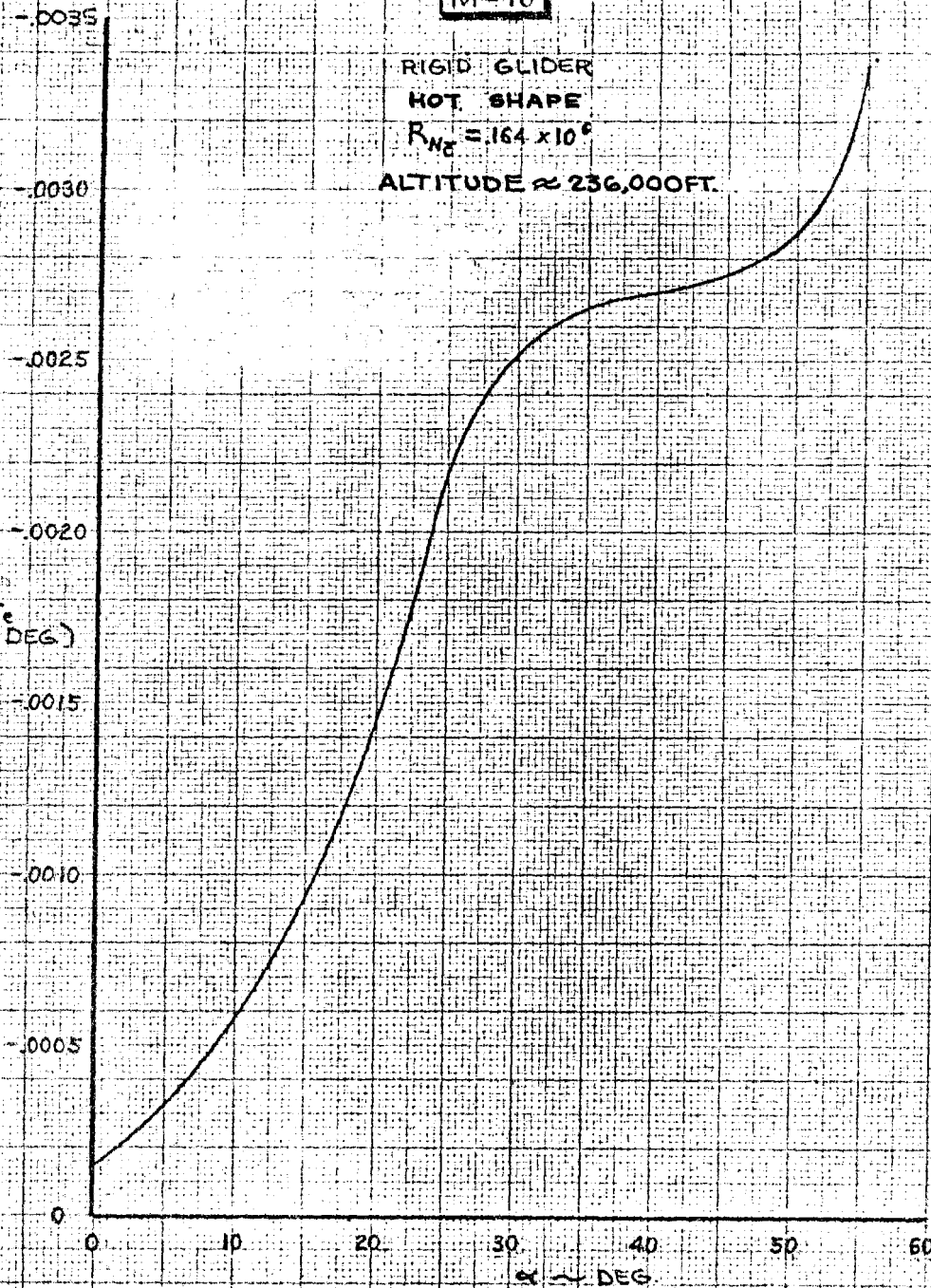


FIG. 6.54

CALC	E.M.P.		REVISED	DATE
CHECK				
APR				
APR				

ELEVON EFFECTIVENESS
ABOUT TRIM
 $M=16$

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PAGE
6.61

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NOTE: SLOPES TAKEN
AT TRIM δ_e

$M=22$

RIGID GUIDER

HOT SHAPE

$R_{H_2} = 1066 \times 10^6$

ALTITUDE $\approx 263,000$ FT.

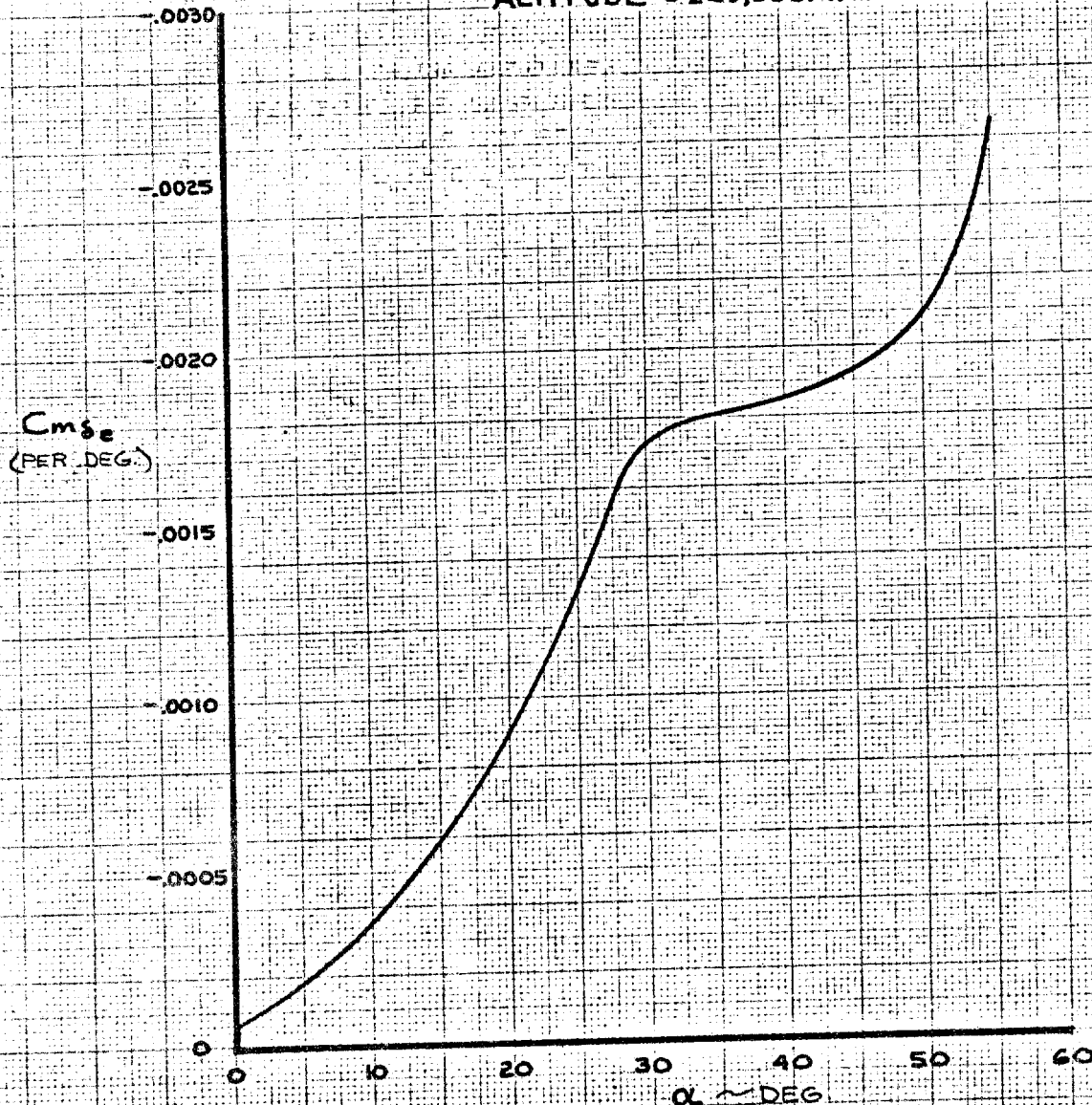


FIG. 6.55

CALC	E.M.P.		REVISED	DATE
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APR				

ELEVON EFFECTIVENESS
ABOUT TRIM
 $M=22$

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2050 D
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$M=6.0$

RIGID GLIDER
NOT L-SHAPE
 $RNE = 8.1 \times 10^5$

ALTITUDE $\approx 165,000$ FT.

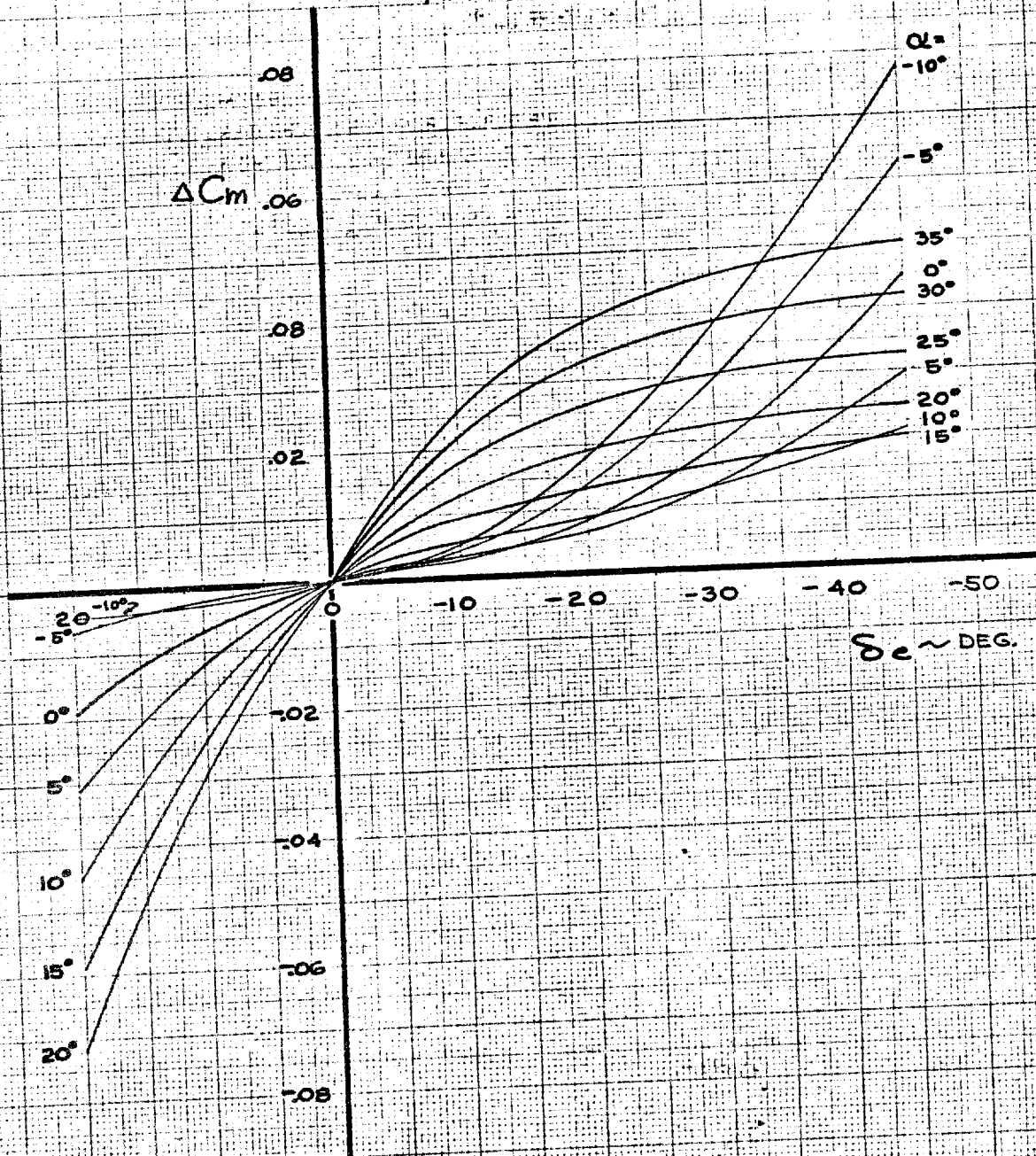


Fig. 6.56

CALC	N.O.	REVISED	DATE
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APR			

ELEVON EFFECTIVENESS
 $M=6.0$

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M=8.0

RIGID GLIDER
HOT SHAPE

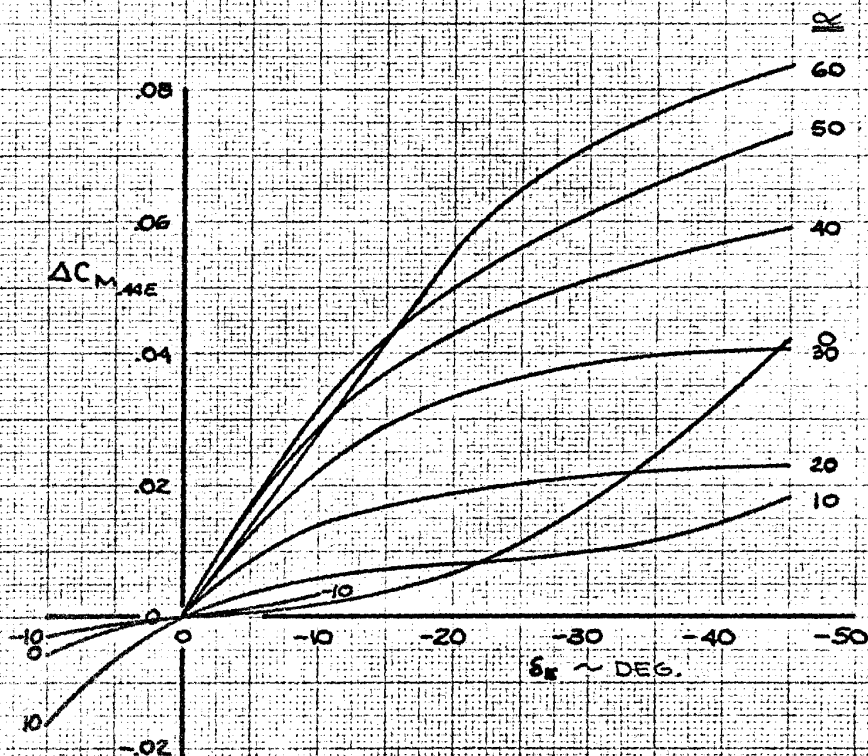


Fig. 6.57

CALC	J.L. FRANCIS	12/13/61	REVISED	DATE
CHECK				
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APR				

ELEVON EFFECTIVENESS
M=8.0

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6.64

US 4013 8000

M=8

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M = 9.0

RIGID GLIDER
NOT SHAPED
RNE = 4.5 X 10⁵

ALTITUDE ≈ 195,000 FT

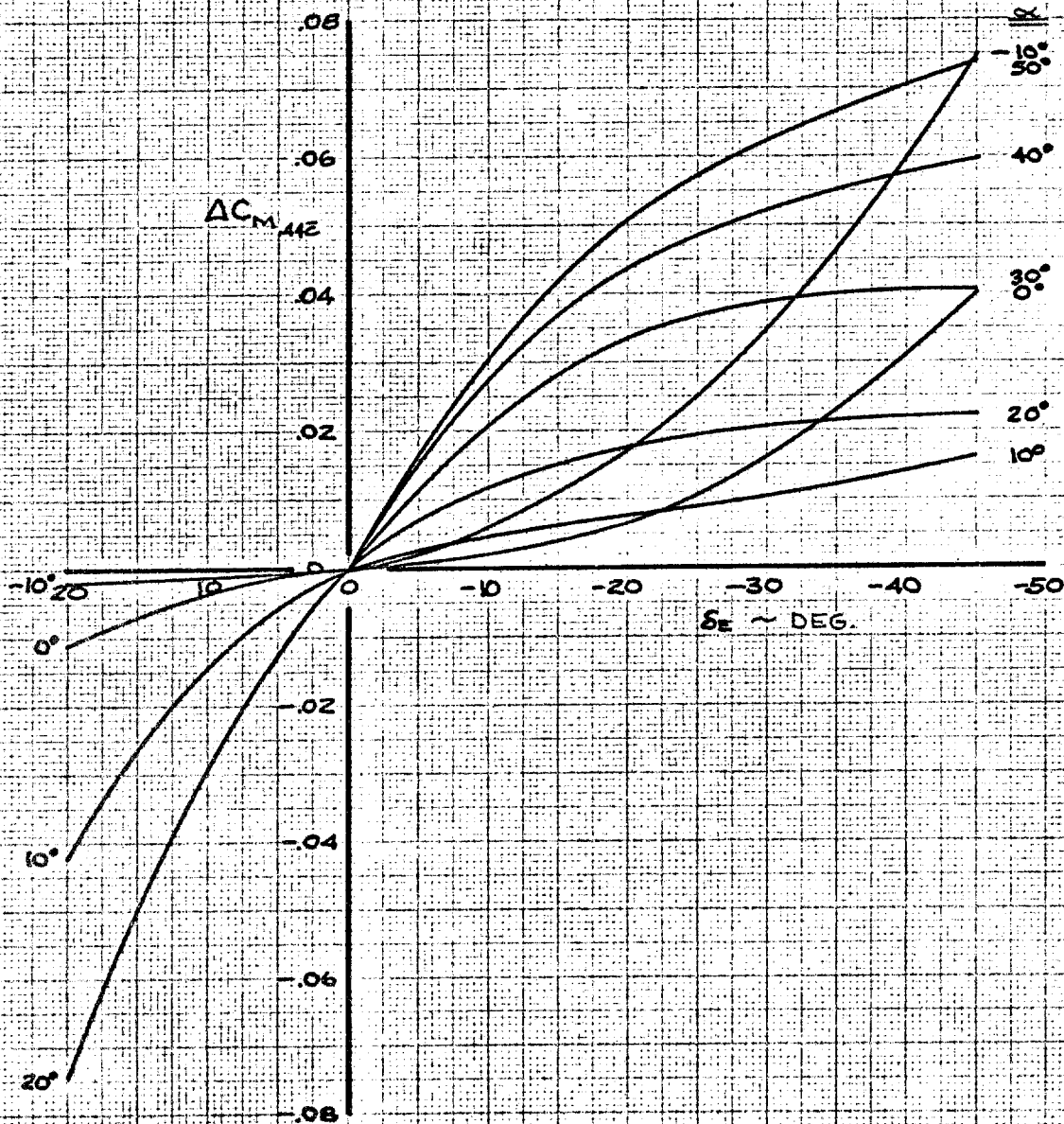


FIG. 6.58

CALC	J.L. FRANCIS	12/13/61	REVISED	DATE
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APR				
APR				

ELEVON EFFECTIVENESS
M = 9.0 - LOW RNE

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6.65

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M=9.0

RIGID GLIDER
HOT SHAPE
 $RN_2 = 8.1 \times 10^5$

ALTITUDE $\approx 180,000$ FT.

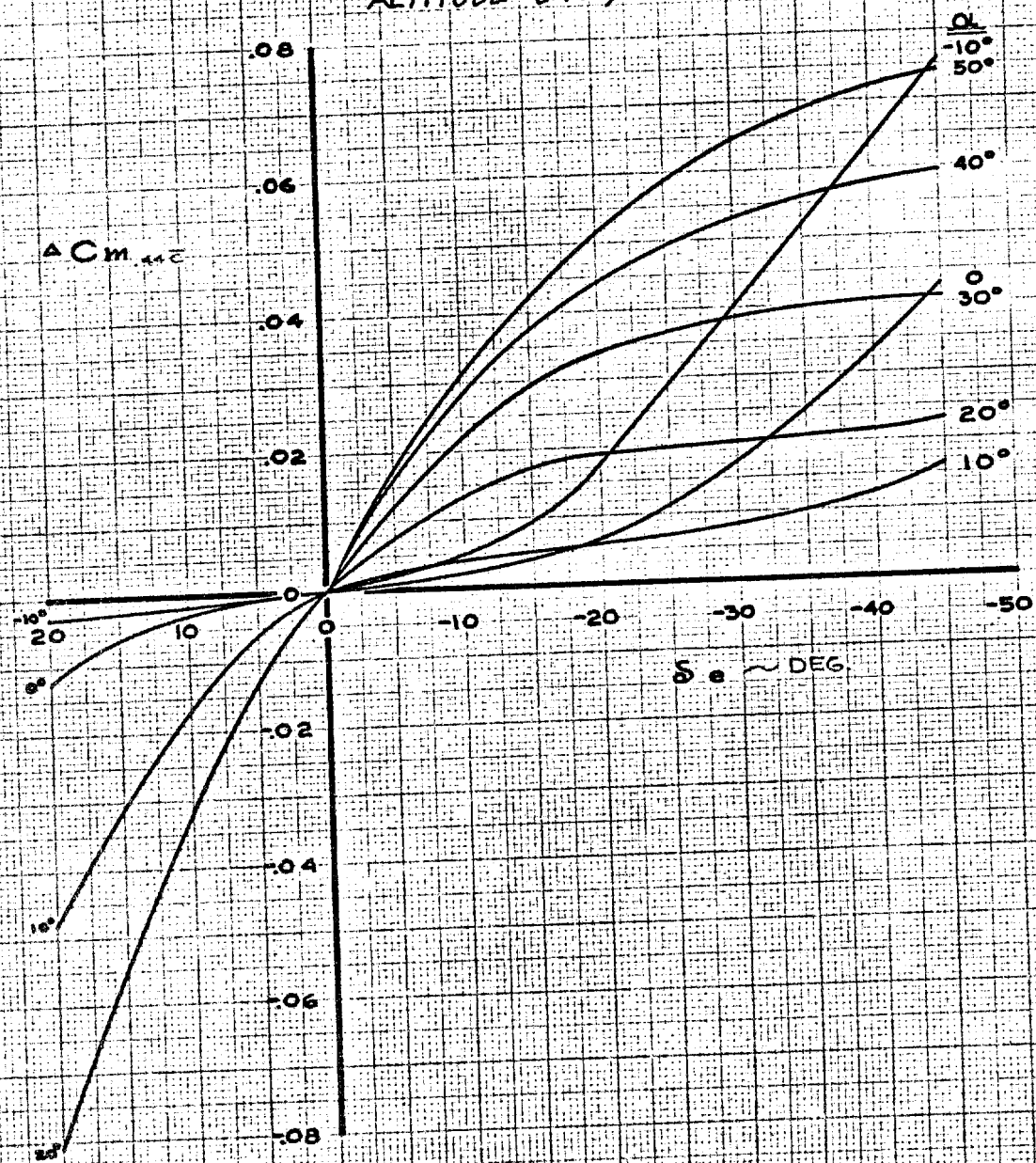


FIG. 6.59

CALC	G.D.K.	REVISED	DATE
CHECK		12-20-51	
APR			
APR			

ELEVON EFFECTIVENESS
 $M = 9.0$

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RIGID GLIDER
NOT SHAPED
 $RN_2 = 4.5 \times 10^5$

ALTITUDE $\approx 195,000$ FT.

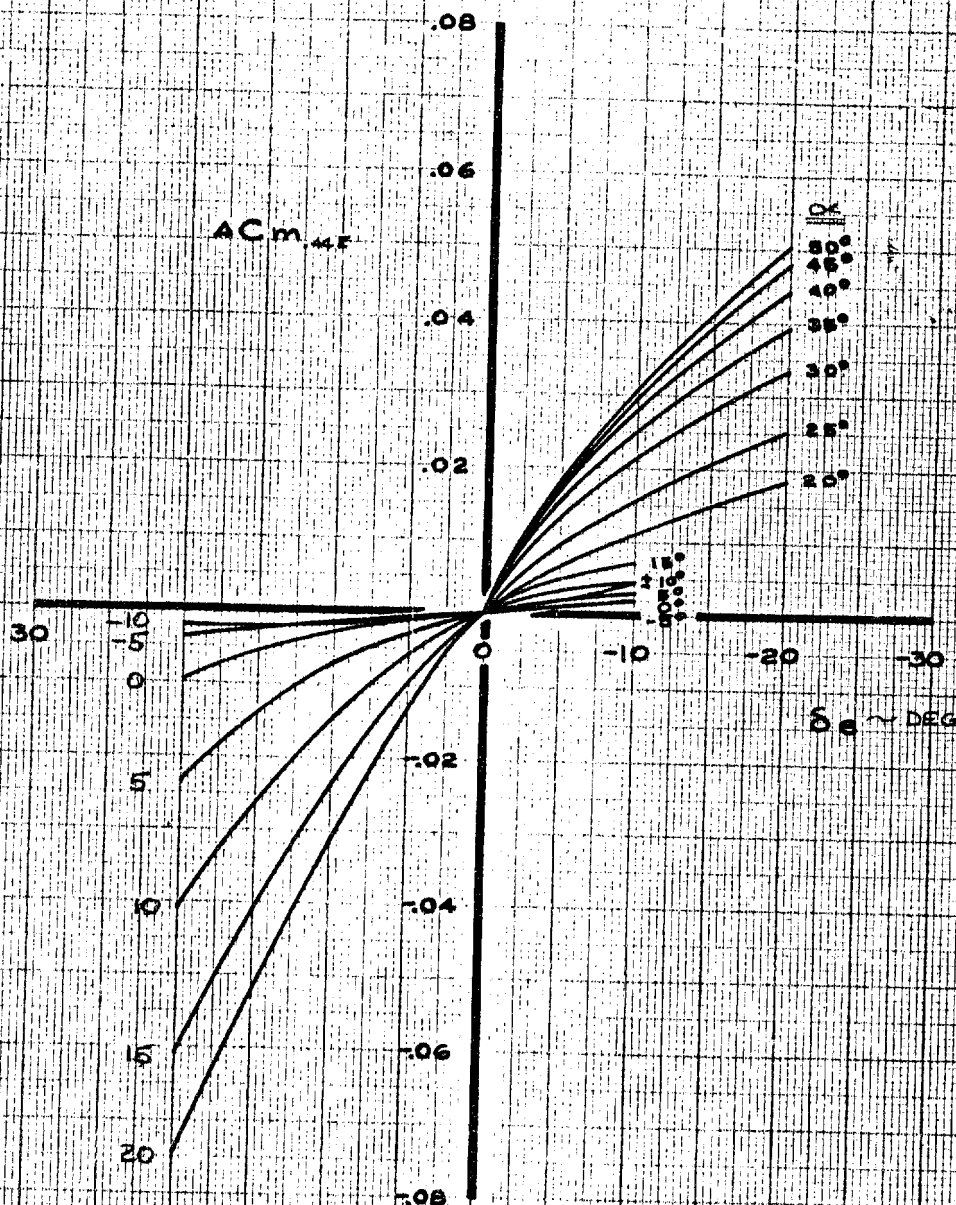


FIG. 6.60

CALC	EMP.	REVISED	DATE	ELEVON EFFECTIVENESS $M = 11$	644 -
CHECK		12-20-1			2050 D
APR					D2-80065
APR					PAGE
				THE BOEING COMPANY	6.67

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M=16

RIGID GLIDER

HOT SHAPE

$R_N = 1.64 \times 10^6$

ALTITUDE $\approx 236,000$ FT.

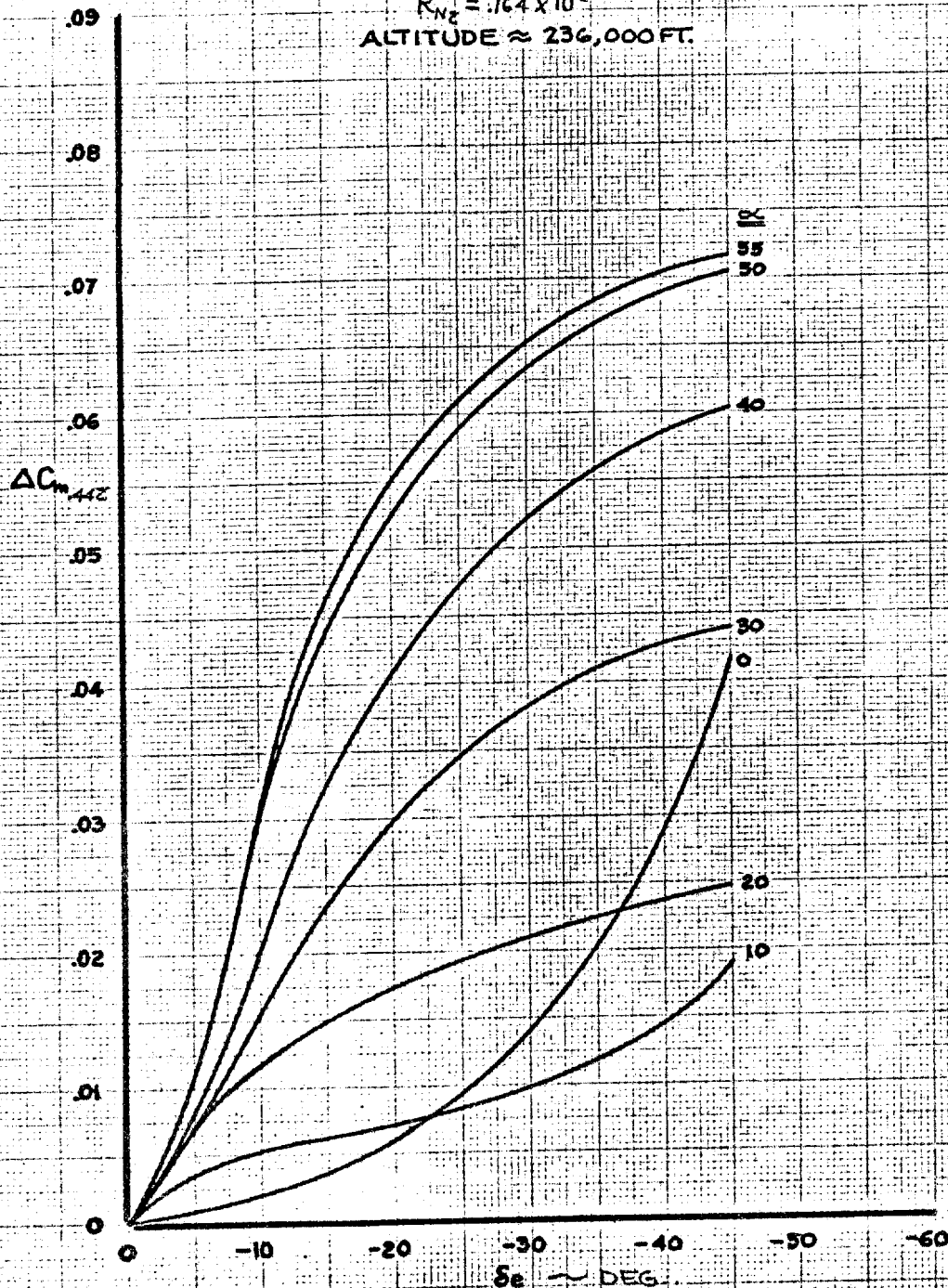


FIG. 6.61

CALC	E.M.P.	REVISED	DATE
CHECK		J.L.F.	12/10/61
APR		12-20-61	
APR			

ELEVON EFFECTIVENESS

M=16

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M=22

RIGID GLIDER

HOT SHAPE

$R_{NE} \approx .066 \times 10^6$

ALTITUDE $\approx 263,000$ FT.

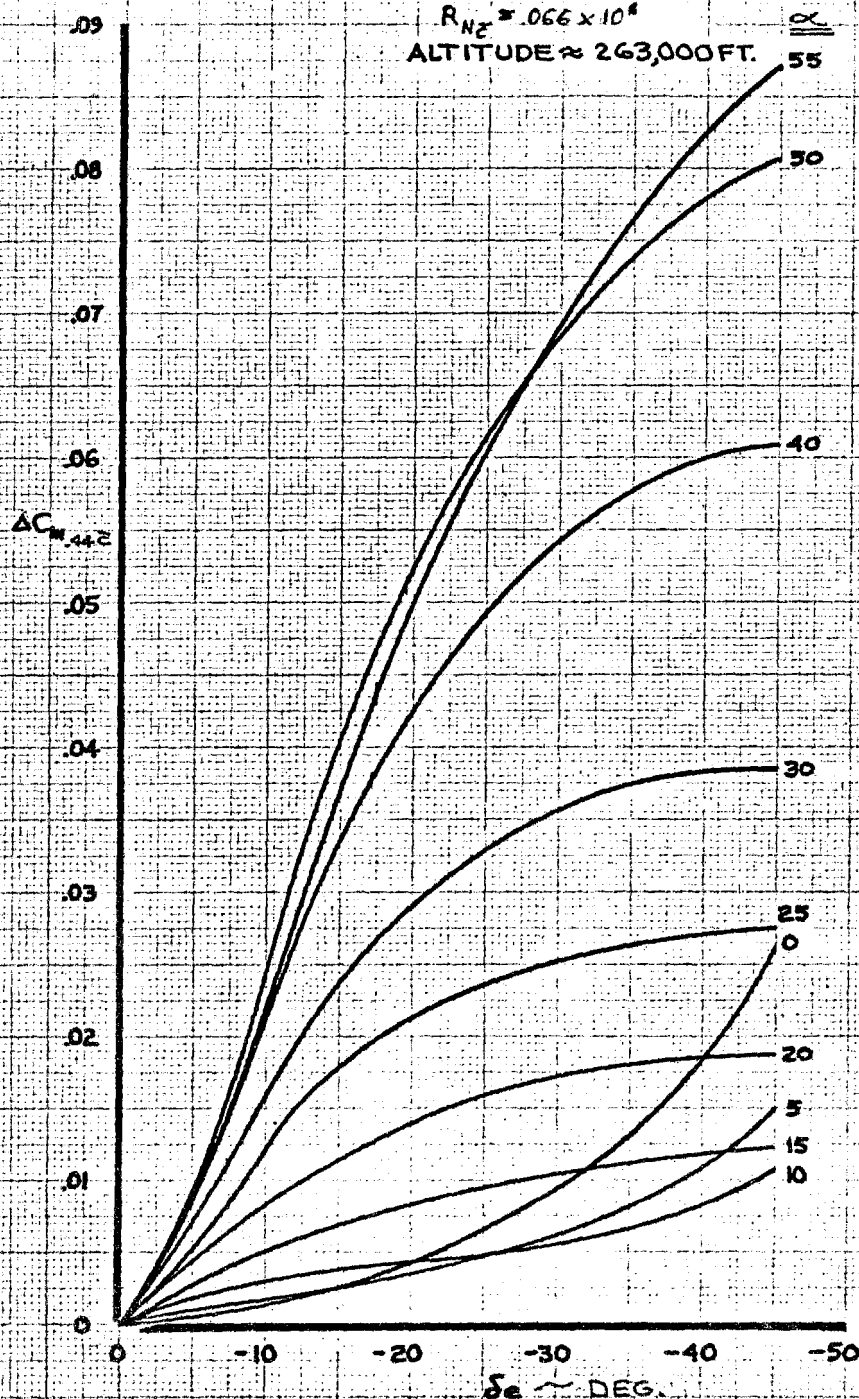


FIG. C.62

CALC	E.M.P.		REVISED	DATE
CHECK			12-2-61	
APR				
APR				

ELEVON EFFECTIVENESS

M=22

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CONFIDENTIAL**6.1.5 ELEVON AS AILERON - PITCH COUPLING**

Effects on normal force and pitching moment of symmetrical elevon deflections about a trim position for subsonic and supersonic speeds are shown in Figure 6.63. These curves are based on wind tunnel data and are applicable through 4 degrees aileron deflection. At larger aileron deflections non-linear characteristics appear.

Hypersonic aileron-pitch coupling effects are shown in Figures 6.64 and 6.65. These curves are based on faired wind tunnel data and are assumed linear to 10 degrees of aileron deflection.

The substantial increase in $C_{m_{\delta_a}}$ from supersonic to hypersonic speeds, Figures 6.63 and 6.64, is attributed primarily to the range of aileron deflections from which the slopes of non linear data were taken. At hypersonic speeds where dynamic pressure is low, a given roll response requires large aileron deflections. Therefore it is more desirable for simulator data inputs to define $C_{m_{\delta_a}}$ over a larger range of aileron deflections.

More refined derivatives can be derived for hypersonic speeds from the data presented in Figures 6.56 through 6.62. Each elevon or aileron should be treated independently. The effect in pitch can be determined by taking one-half the incremental moment between the trimmed elevon position and the deflected aileron position. Summing these two increments algebraically gives the total aileron effect on pitching moment.

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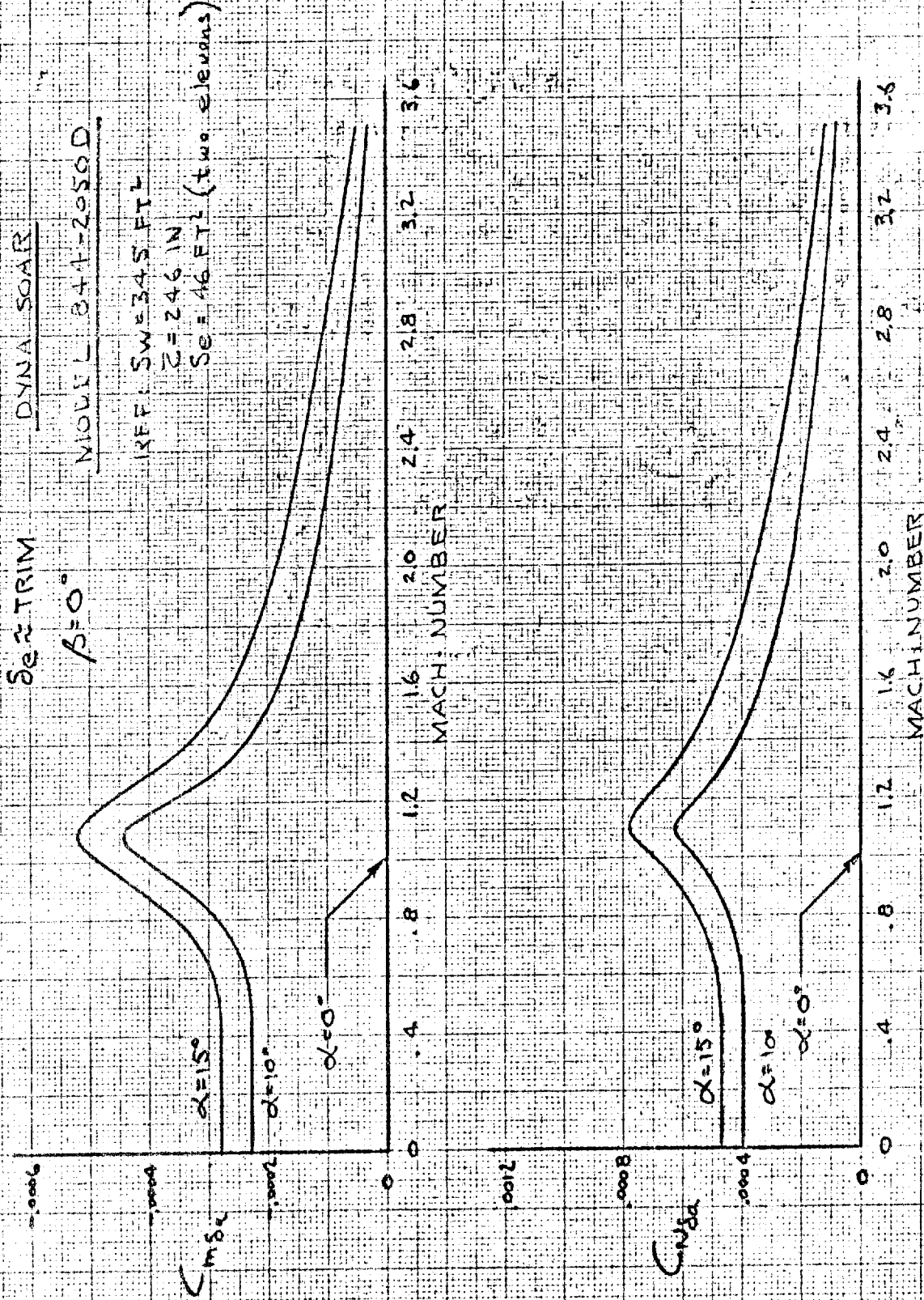


FIG. G.63

CALC	EVH	12/15/11	REVISED	DATE
CHECK			12-20-1	
APR				
APR				

AILERON/PITCH COUPLING
SUBSONIC THROUGH SUPERSONIC

844-2050D
D2-80065
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THE BOEING COMPANY

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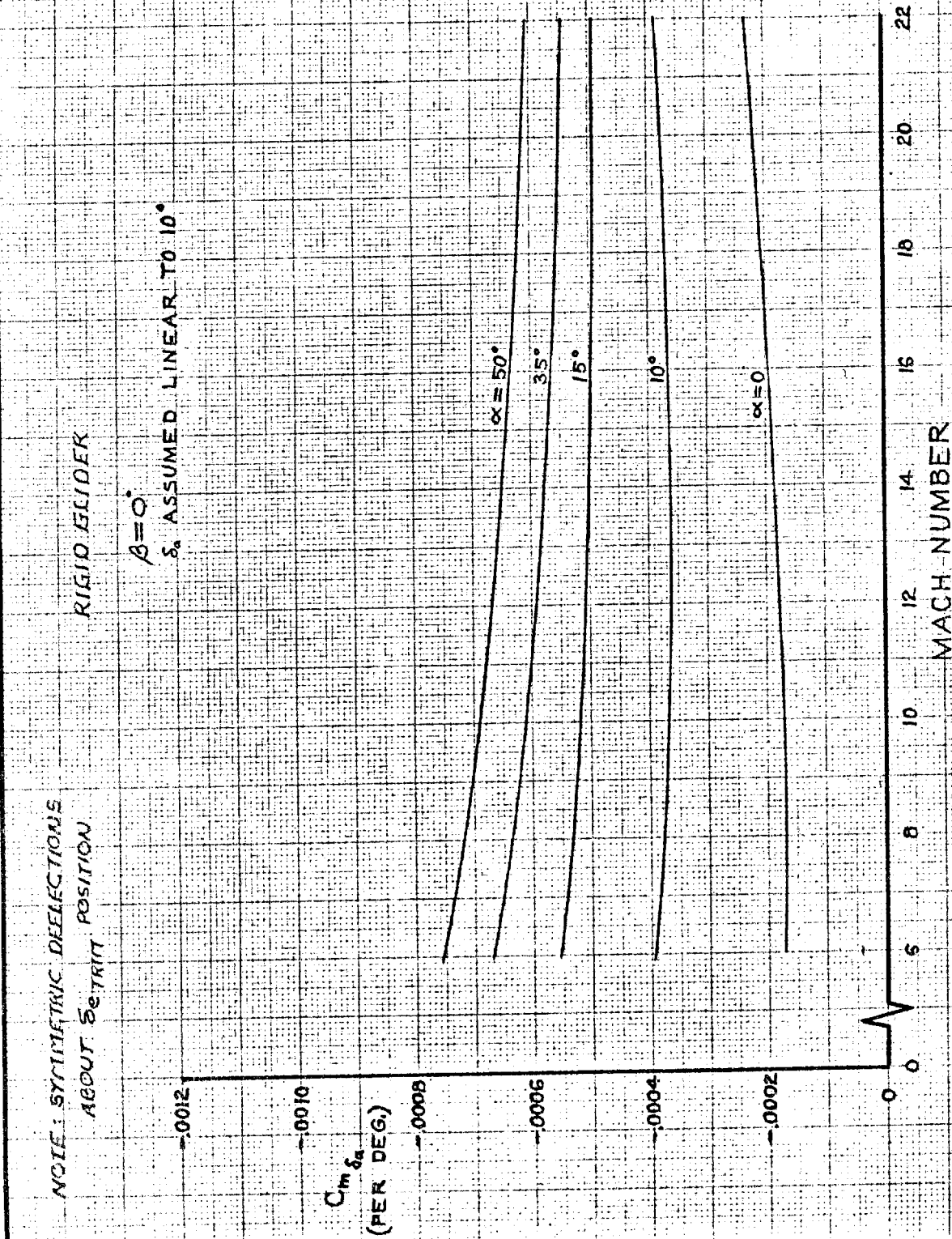


FIG. 6.6A

CALC	WJK	12-12-61	REVISED	DATE
CHECK			12-12-61	
APR				
APR				

AILERON/PITCH COUPLING
PITCHING MOMENT
HYPERSONIC

THE BOEING COMPANY

844-
2050 D
DR-80065
PAGE
6.72

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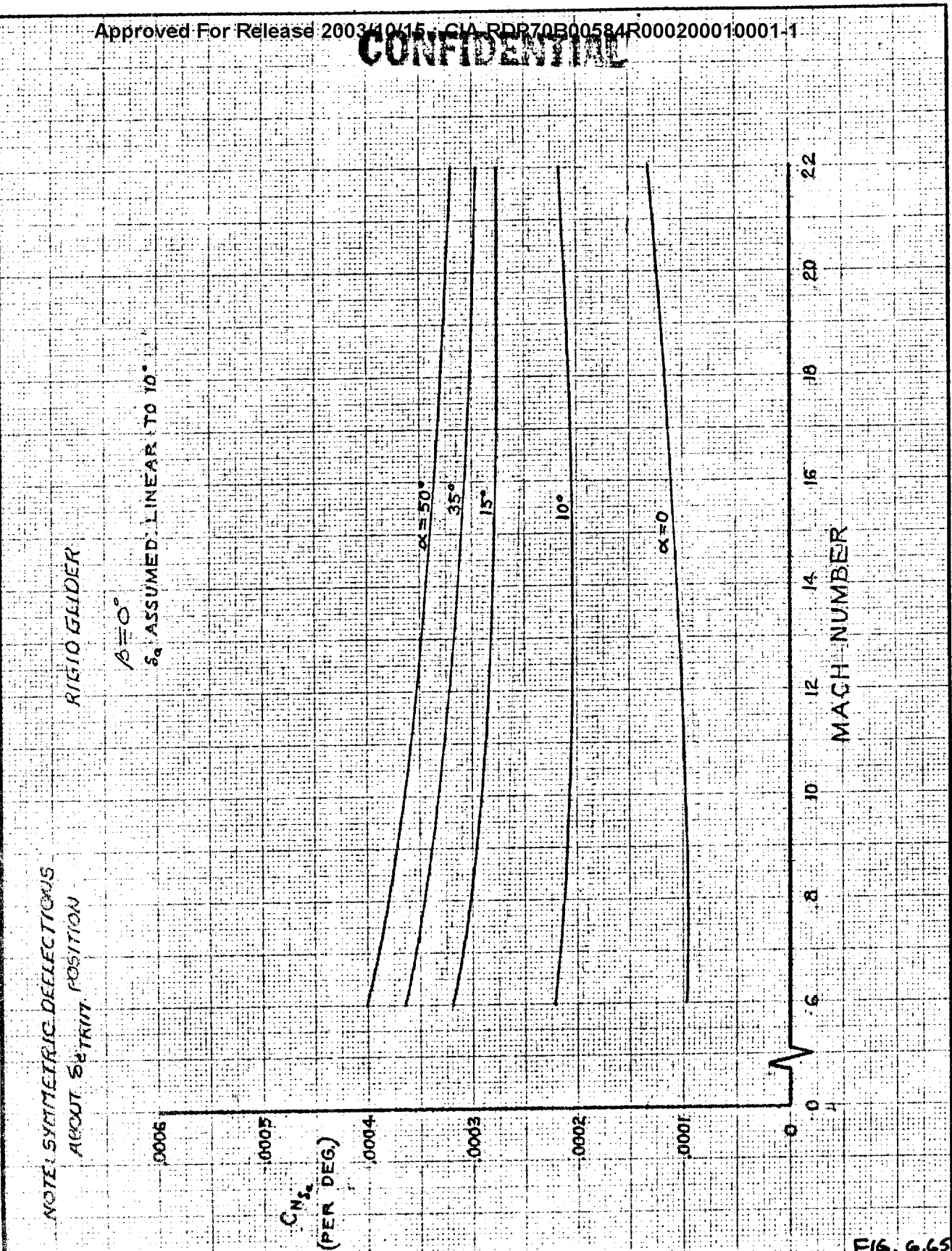


FIG. 6.65

CALC	LDK	12-12-61	REVISED	DATE
CHECK			12-22-61	
APR				
APR				

AILERON/PITCH COUPLING
NORMAL FORCE
HYPERSONIC

THE BOEING COMPANY

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2050-D
DR-8065
PAGE
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6.1.6 ROTARY DERIVATIVES

Pitch damping derivative $C_{m\dot{\alpha}}$, shown in Figure 6.66, was obtained from NASA reports of similar configurations. These data were also compared with linear theory which showed reasonable agreement at supersonic speeds but was nearly double the empirical value at subsonic speeds. Data from Langely Research Center Free Flight Wind Tunnel showing the effects of angle of attack and oscillation frequency on $C_{m\dot{\alpha}}$ and $C_{m\ddot{\alpha}}$ are shown in Figure 6.67. Additional theoretical and experimental work is planned to further define these derivatives.

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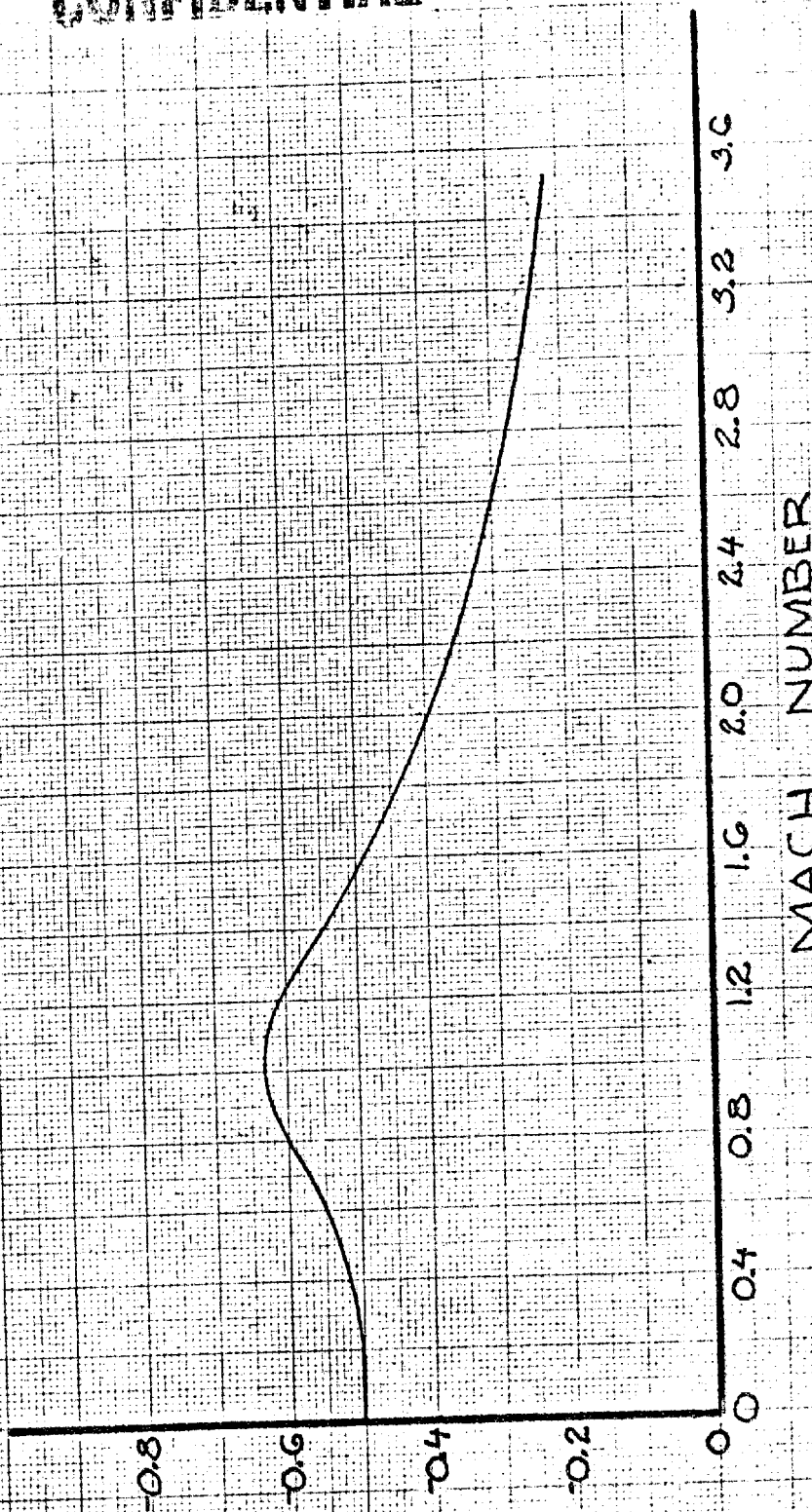
DYNA-SOAR
MODEL 844-2050C

$$C_{mq} = \frac{\partial C_m}{\partial \left(\frac{\theta \bar{c}}{2V} \right)}$$

$$\bar{c} = 246 \text{ IN.}$$

$$CG = 1.44 \bar{c}$$

C_{mq} - PER RADIAN



MACH NUMBER

FIG. 6.66

CALC	SAKATA	3-30-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				
TRACED				

PITCHING MOMENT DUE
TO PITCHING VELOCITY

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12-80065
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$M = 0.06$

LANGLEY DATA
2002 CONFIG.
C.G. = 67.5% CR

$\frac{Wb}{2V} = 0.10$

$\frac{Wb}{2V} = 0.15$

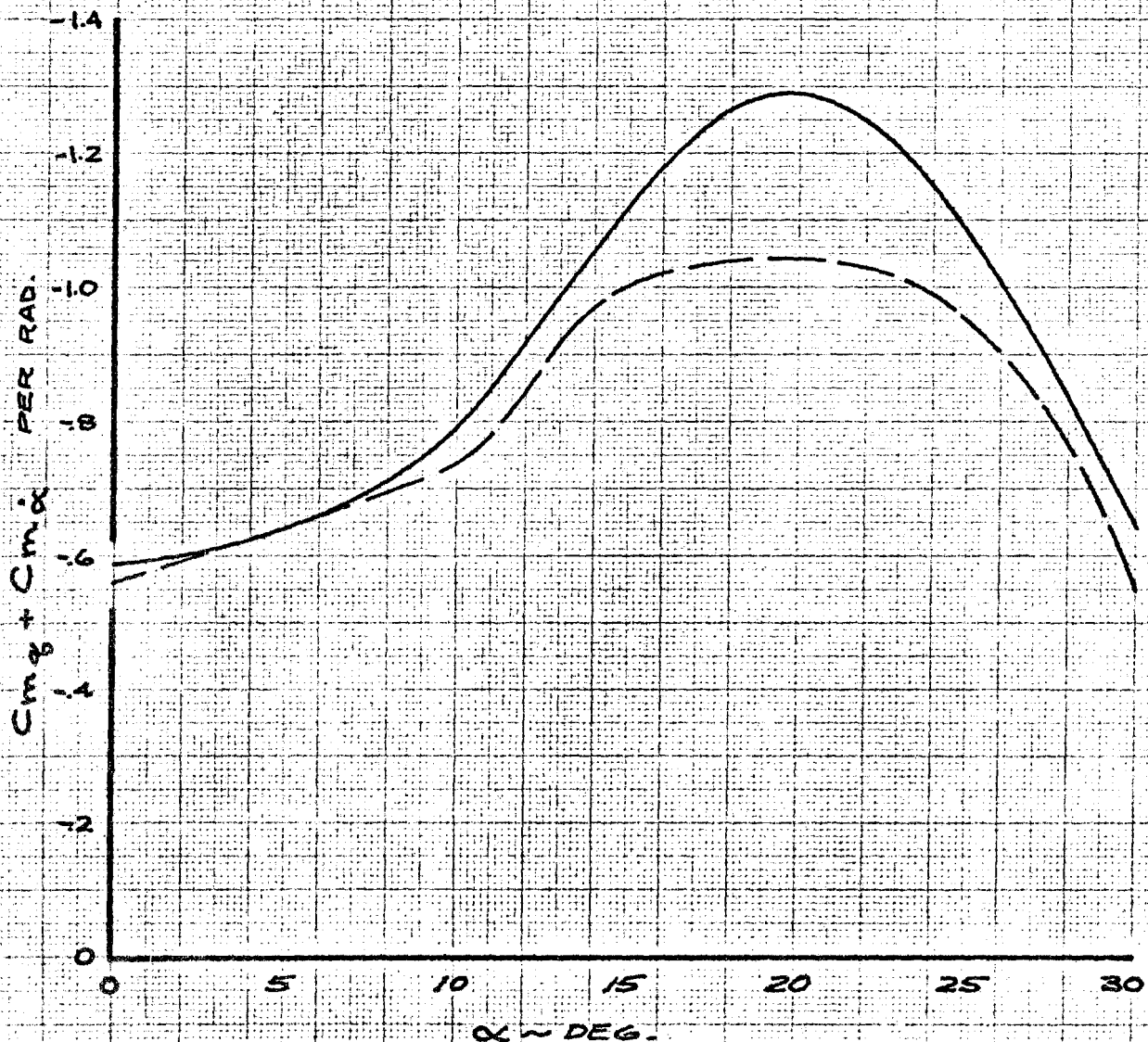


FIG. 6.67

CALC	SAHATA	3-30-61	REVISED	DATE	PITCHING MOMENT DUE TO PITCHING VELOCITY LOW SPEED	844- 2050D
CHECK			12-2-61			D2-80065
APR						PAGE
APR						6.76
DRN	R. RICE	12-18-61			THE BOEING COMPANY	

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CONFIDENTIAL**6.1.7****ELEVON HINGE MOMENT CHARACTERISTICS**

The elevon hinge moment coefficients are for the current glider configuration, 844-2050D.

The data used for the curves presented in Figures 6.68 through 6.88 consists of wind tunnel data obtained at the Boeing Transonic and Supersonic Tunnels, Tests BTWT 685 and BSWT 113 and then modified to the 844-2050D rigid glider.

The curves for the hinge moment derivatives $C_{H\delta}$, $C_{H\delta_e}$ and $C_{H\alpha}$, as shown in Figures 6.68 through 6.70, and the curve for the coefficient C_{H_0} , as shown in Figure 6.71, summarize the change in the linearized coefficient data with a variation in Mach number. All data are based on an elevon 2 Ma value equal to 1222 in-ft. sq. and an area equal to 22.9 ft. sq. per elevon.

Detailed elevon hinge moment coefficients and their variation with elevon deflection (δ_e) and glider angle of attack (α) are shown in Figures 6.72 through 6.80. These data are not linear for the transonic speed range of Mach number equal to .90 through 1.1.

Figures 6.81 through 6.88 show the relationship between elevon trim position and elevon float position and may be used to determine the elevon actuator load reversal points. The elevon required to trim information is a repeat of data in section 6.1, Longitudinal Stability and Control.

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DYNA-SOAR MODEL 844-2050D

CH_A IS NEGATIVE FOR RIGHT ELEVON
" " IS POSITIVE FOR LEFT ELEVON

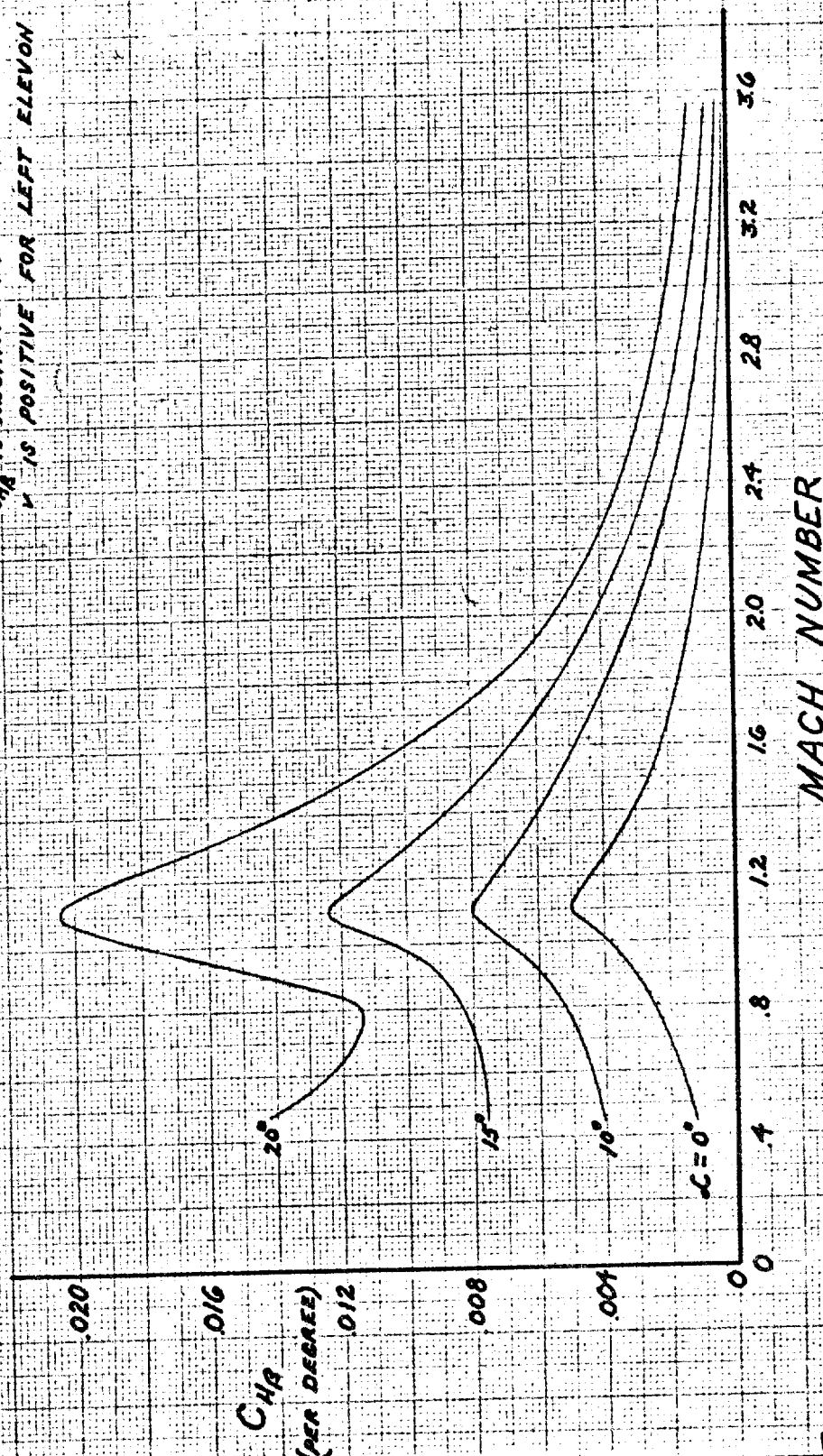


FIG. 6.68

CALC	12-7-61	REVISED	DATE
CHECK		12-20-61	
APR			
APR			

EFFECT OF MACH NUMBER ON
ELEVON HINGE MOMENT DERIVATIVE
CH_A

BOEING AIRPLANE COMPANY

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DYNA-SOAR MODEL 844-2050D

$\alpha = 0^\circ$
 $\beta = 0^\circ$

ELEVON $2Mq = 1222 \text{ IN}^2 \text{ FT}^2$
ELEVON AREA = $22.9 \text{ FT}^2 / \text{SIDE}$

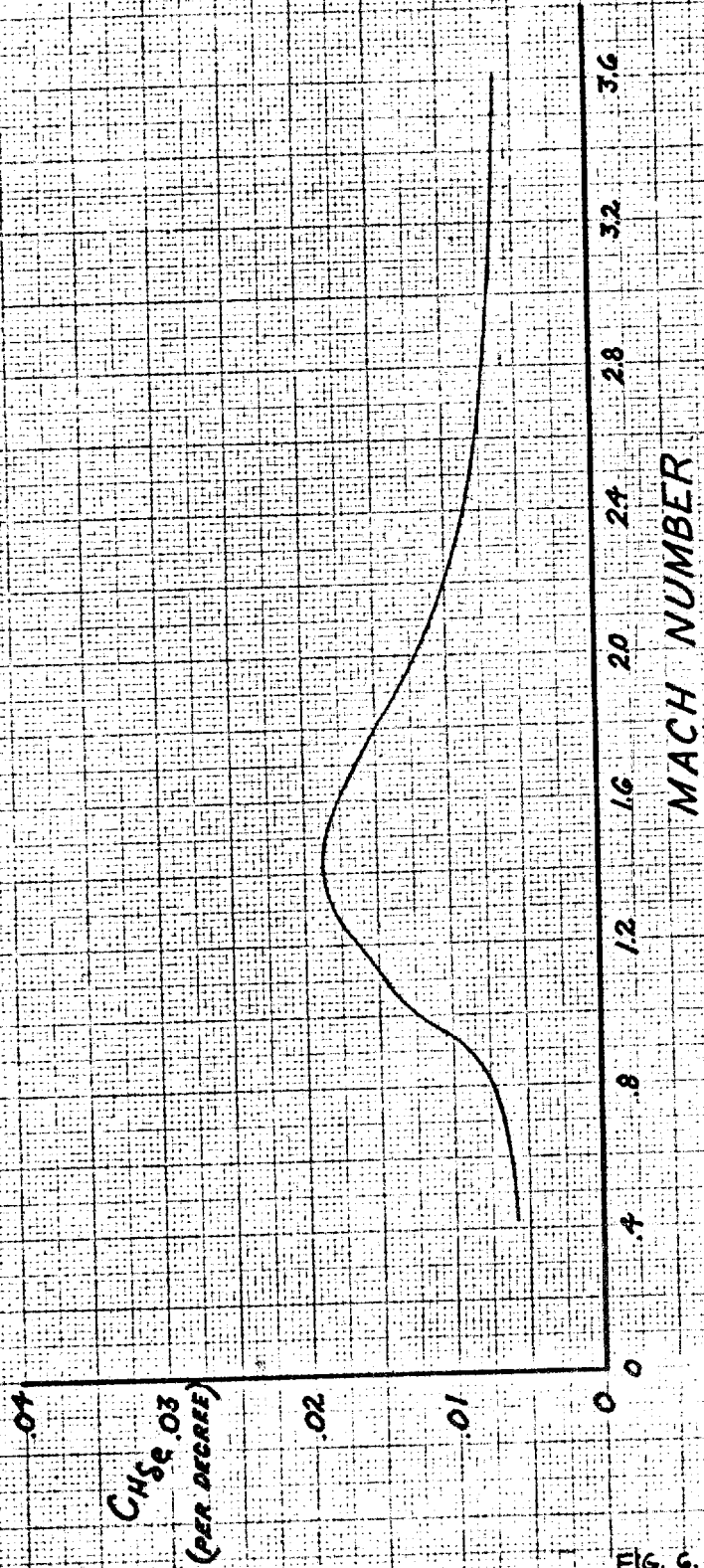


FIG. 6.69

CALC	<i>Prop. G.C.</i>	12-7-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

EFFECT OF MACH NUMBER ON
ELEVON HINGE MOMENT DERIVATIVE

BOEING AIRPLANE COMPANY

844-2050D

D2-80065

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6.79

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DYNA-SOAR MODEL 844-2050 D

$\delta_e = 0^\circ$, $\beta = 0^\circ$

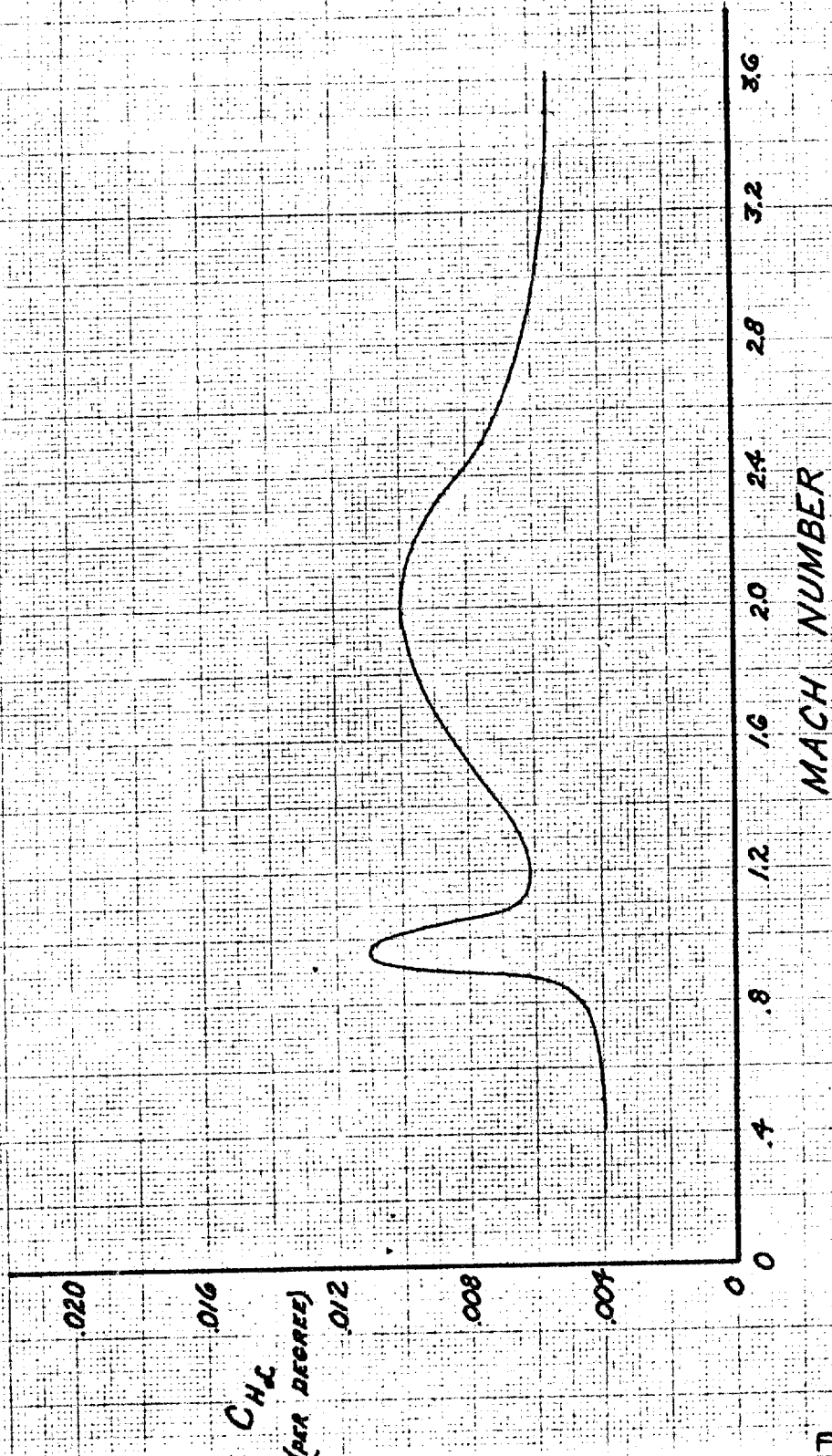


FIG. 6.70

CALC	<i>Handwritten</i>	11-7-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

EFFECT OF MACH NUMBER ON
ELEVON HINGE MOMENT DERIVATIVE

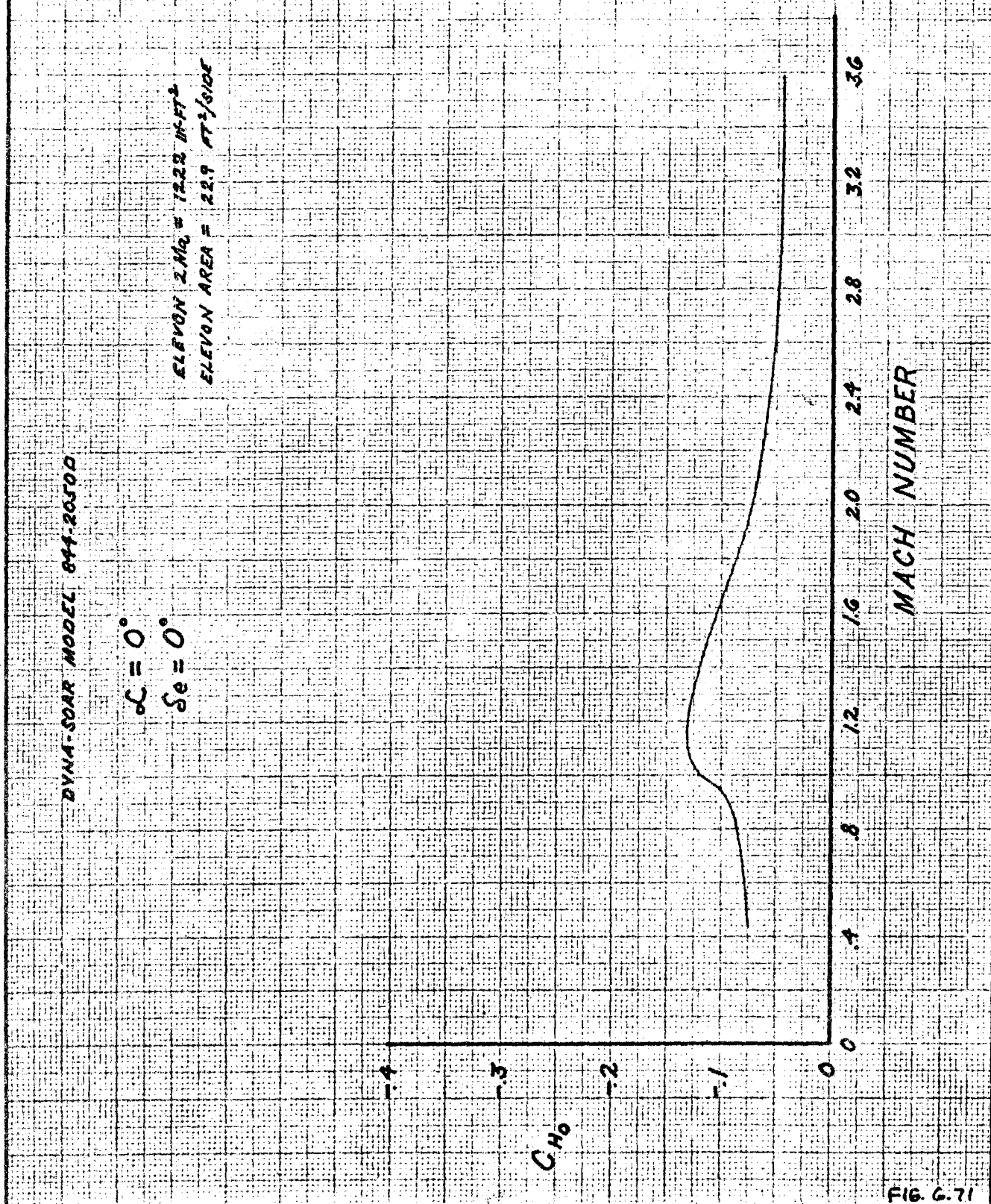
CH_L

THE BOEING COMPANY

844-2050 D
12-80065
PAGE
6.80

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CALC	<i>Hand 48.</i>	12-7-61	REVISED	DATE	EFFECT OF MACH NUMBER ON ELEVON HINGE MOMENT COEFFICIENT $L = 0^\circ$, $S_e = 0^\circ$ BOEING AIRPLANE COMPANY	844-2050D
CHECK			12-20-61			D2-80065
APR						PAGE
APR						6.81

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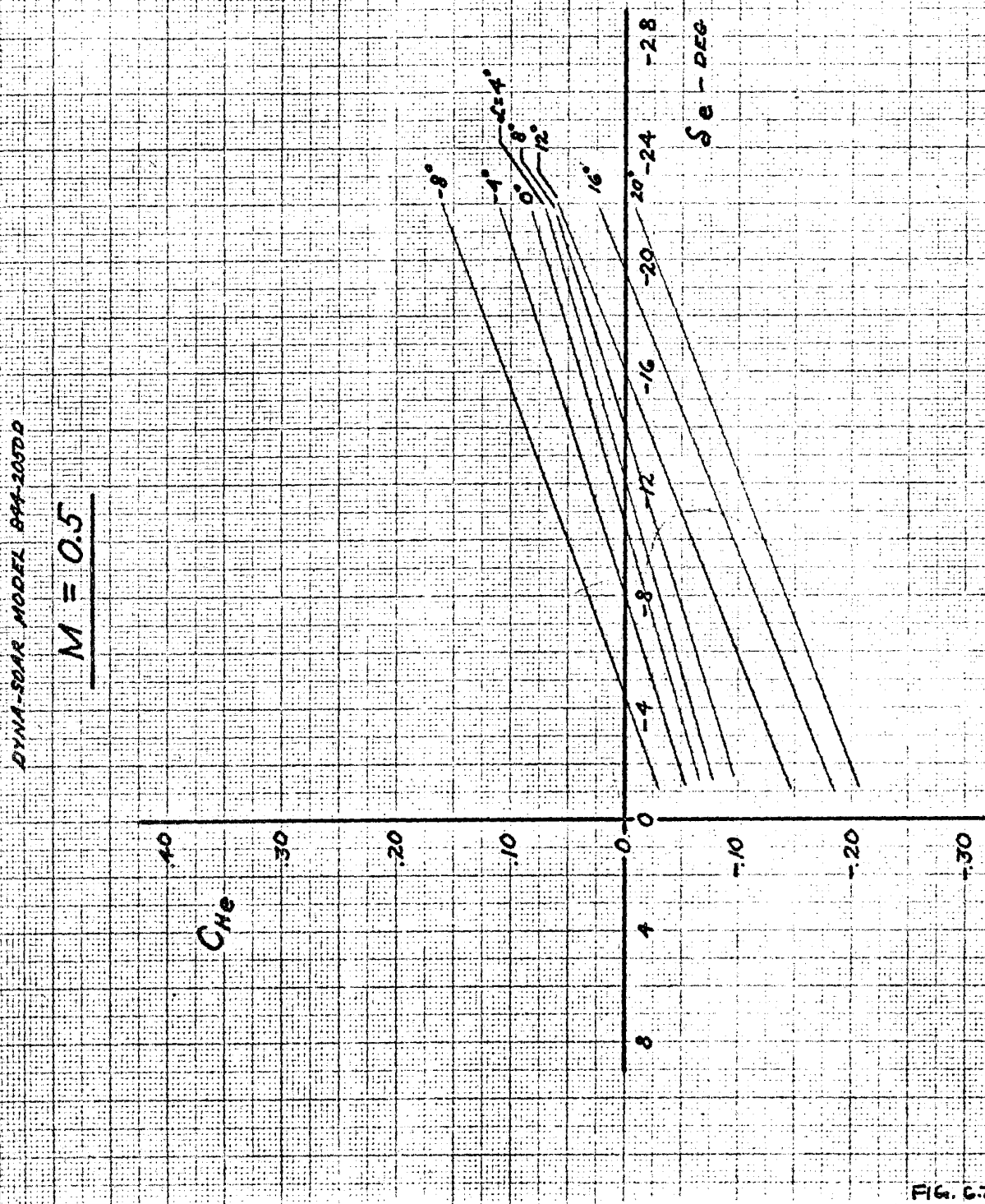


FIG. C.72

CALC	<i>Handwritten initials</i>	11-6-61	REVISED	DATE	EFFECT OF ELEVON DEFLECTION ON HINGE MOMENT $M = 0.50$	844-2050D
CHECK			12-6-61			D2-80065
APR						PAGE
APR						C.82
					THE BOEING COMPANY	

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DYNA-SMAR MODEL 844-20500

$M = 0.8$

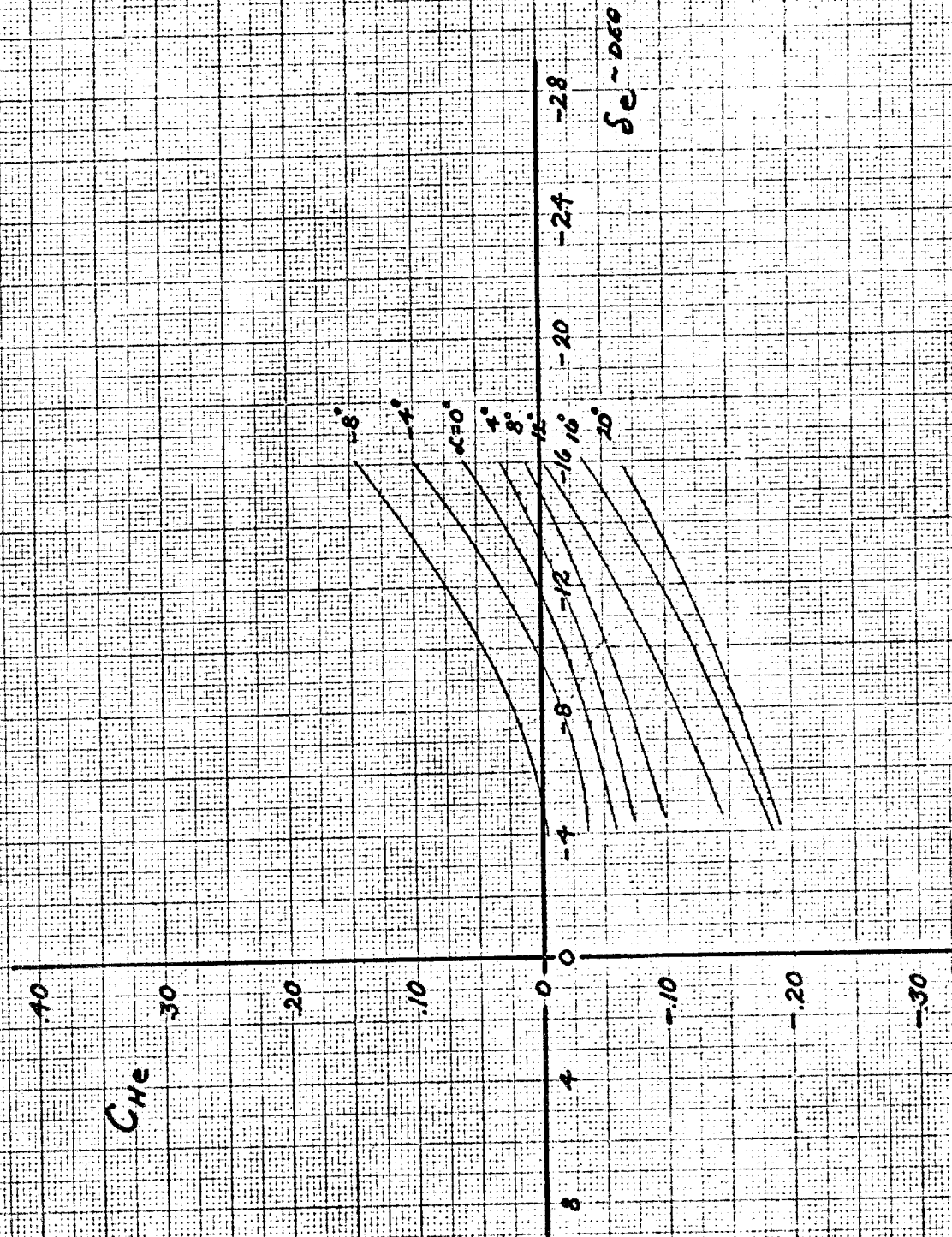


FIG. 6.73

CALC	For 0.8	11.6.61	REVISED	DATE
CHECK			12-20-1	
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
 $M = 0.80$

THE BOEING COMPANY

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6.83

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W, B, E, V, 2050

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DYNA-SOAR MODEL 844-20500

$M = 0.90$

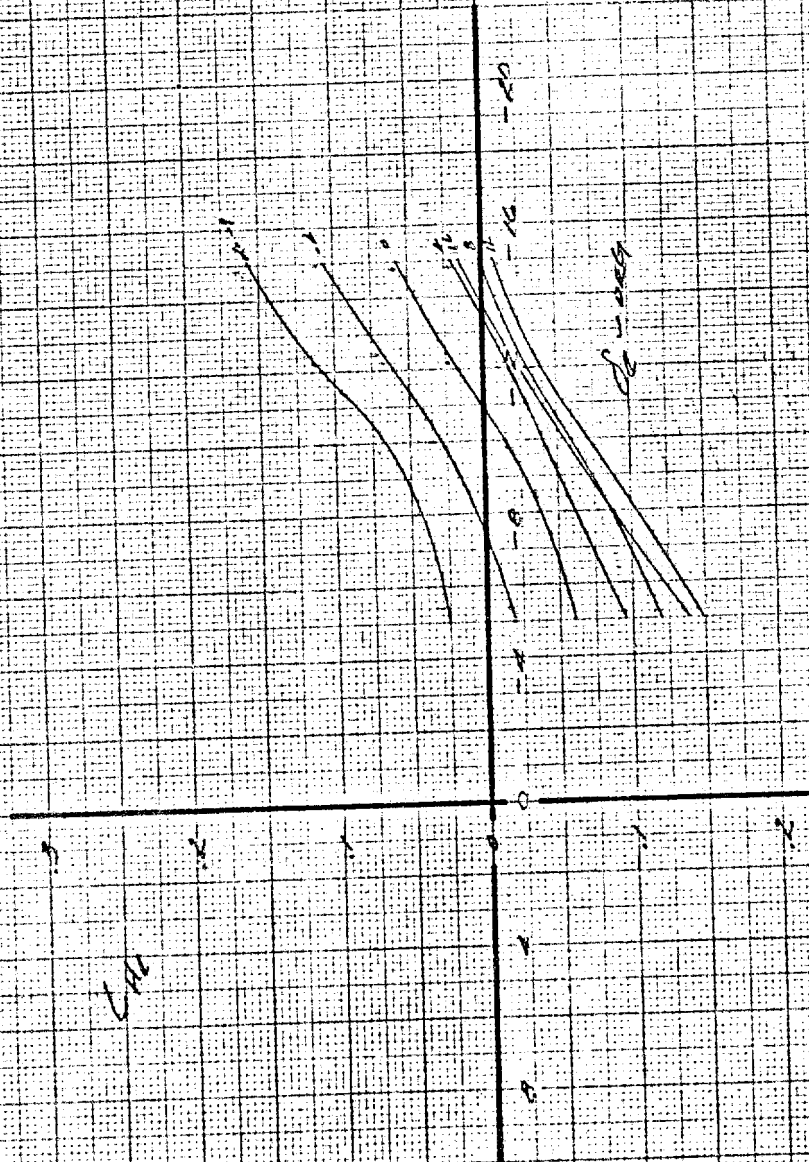


FIG. 6.14

CALC	JANATA	REVISED	DATE
CHECK		12-2-1	
APR			
APR			

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
 $M = 0.90$

THE BOEING COMPANY

844-20500

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6.84

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DYNA-SOAR MODEL 844-2050D

M = 0.95

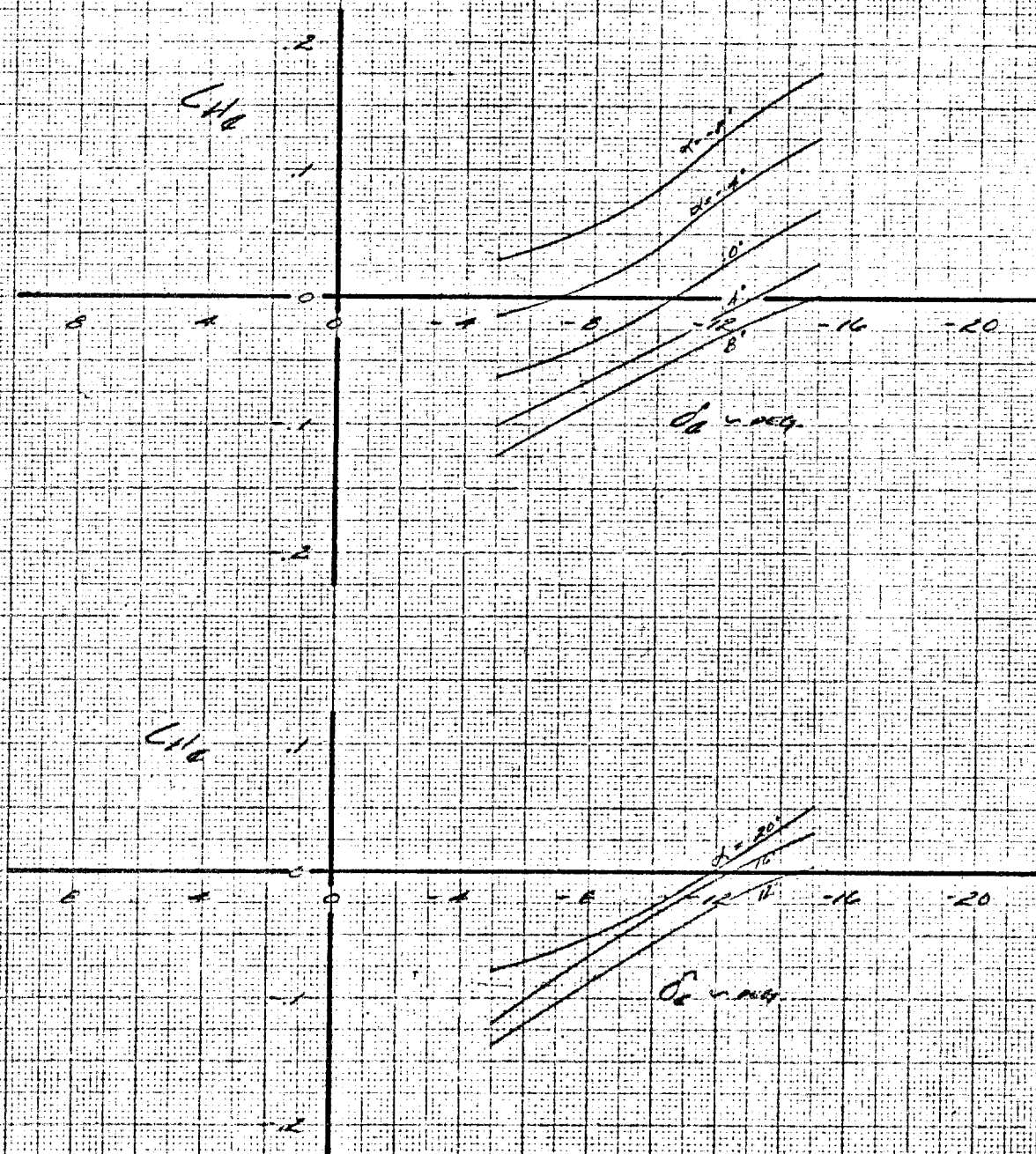


FIG. 6.75

CALC	DATA	N. 2.1	REVISED	DATE
CHECK			12-20-1	
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
M = 0.95

844-2050D

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DYNA-SOAR MODEL 844-20500

$M = 1.00$

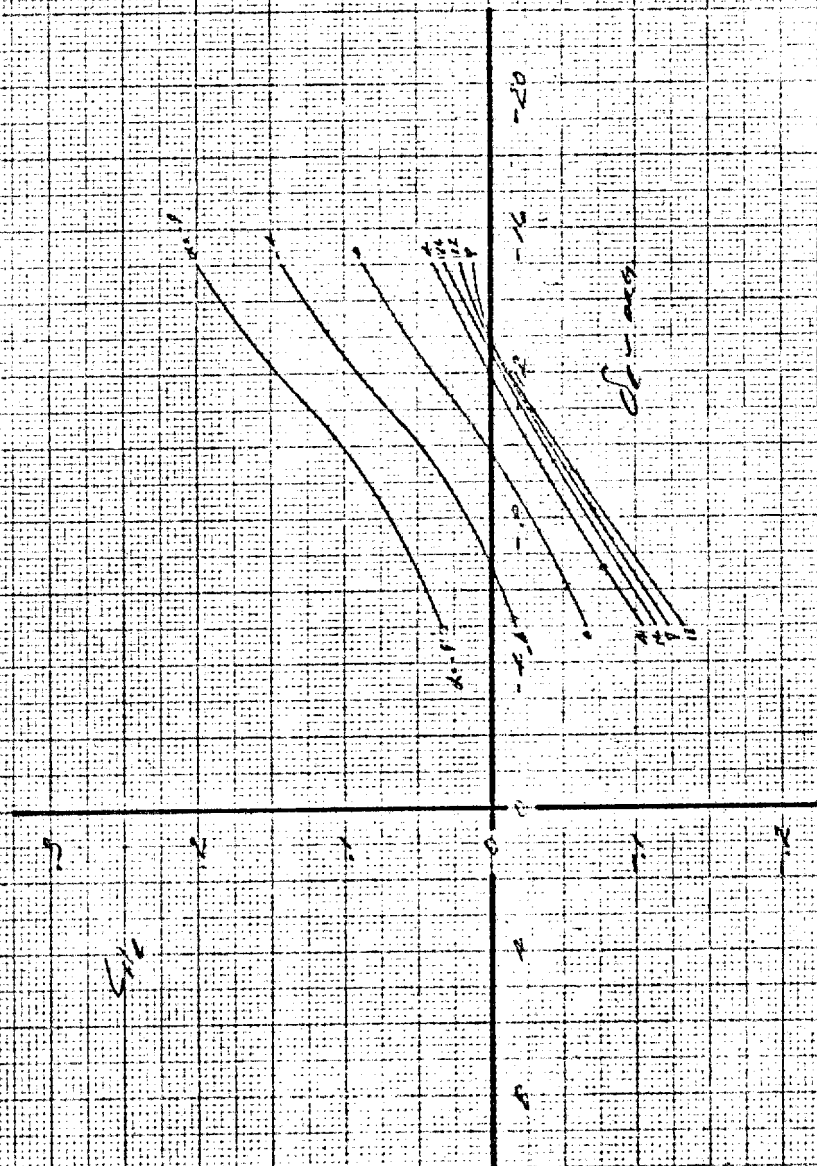


FIG. G.76

CALC	JDW	4-7-1	REVISED	DATE
CHECK			12-2-1	
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
 $M = 1.00$

THE BOEING COMPANY

844-20500

02-80065

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DYNA-SOAR MODEL 844-20500

$M = 1.1$

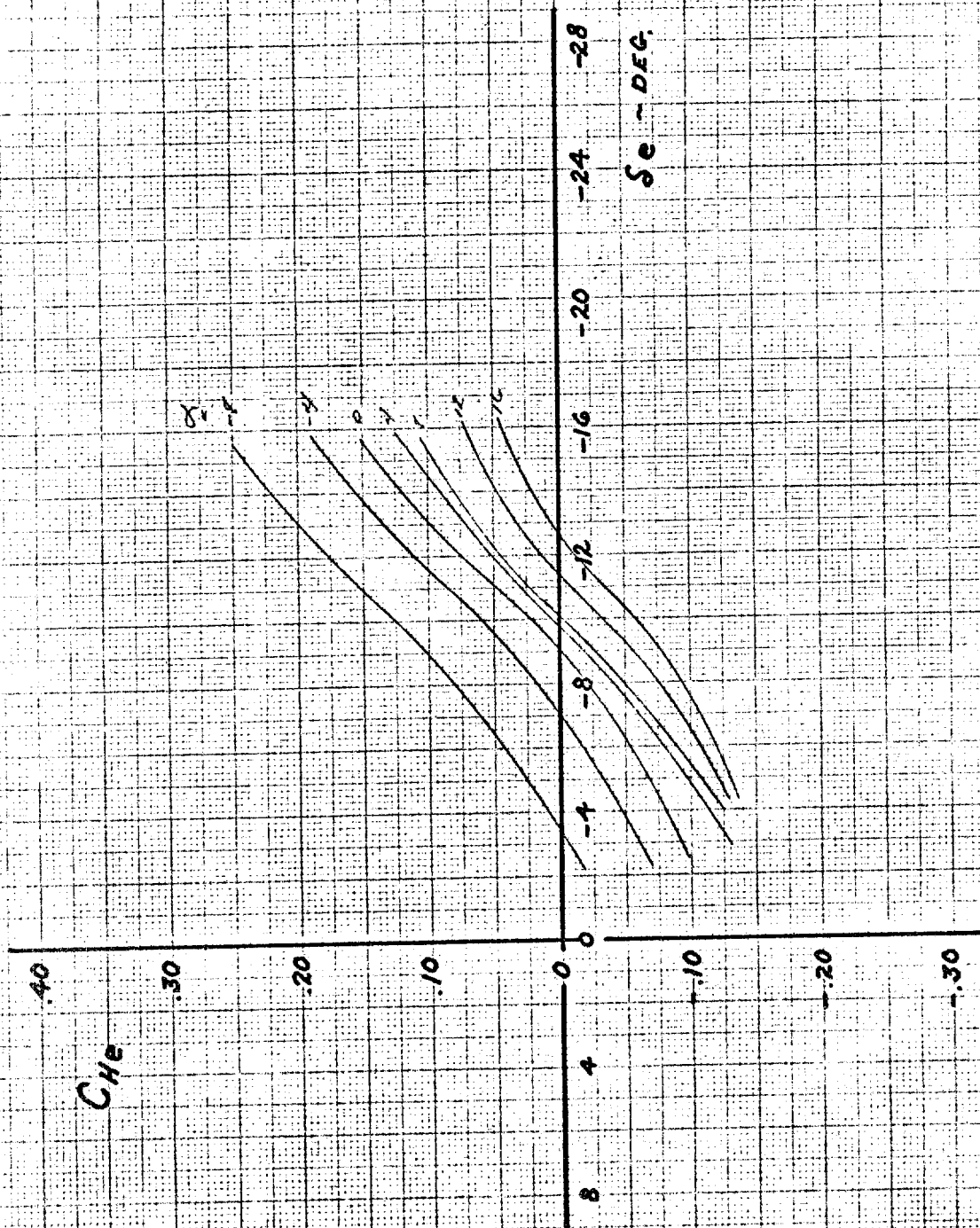


FIG. 6.77

CALC	<i>Hand A.C.</i>	11-3-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
 $M = 1.10$

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6.87

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DYNA-SOAR MODEL 844-2050D

$M = 1.4$

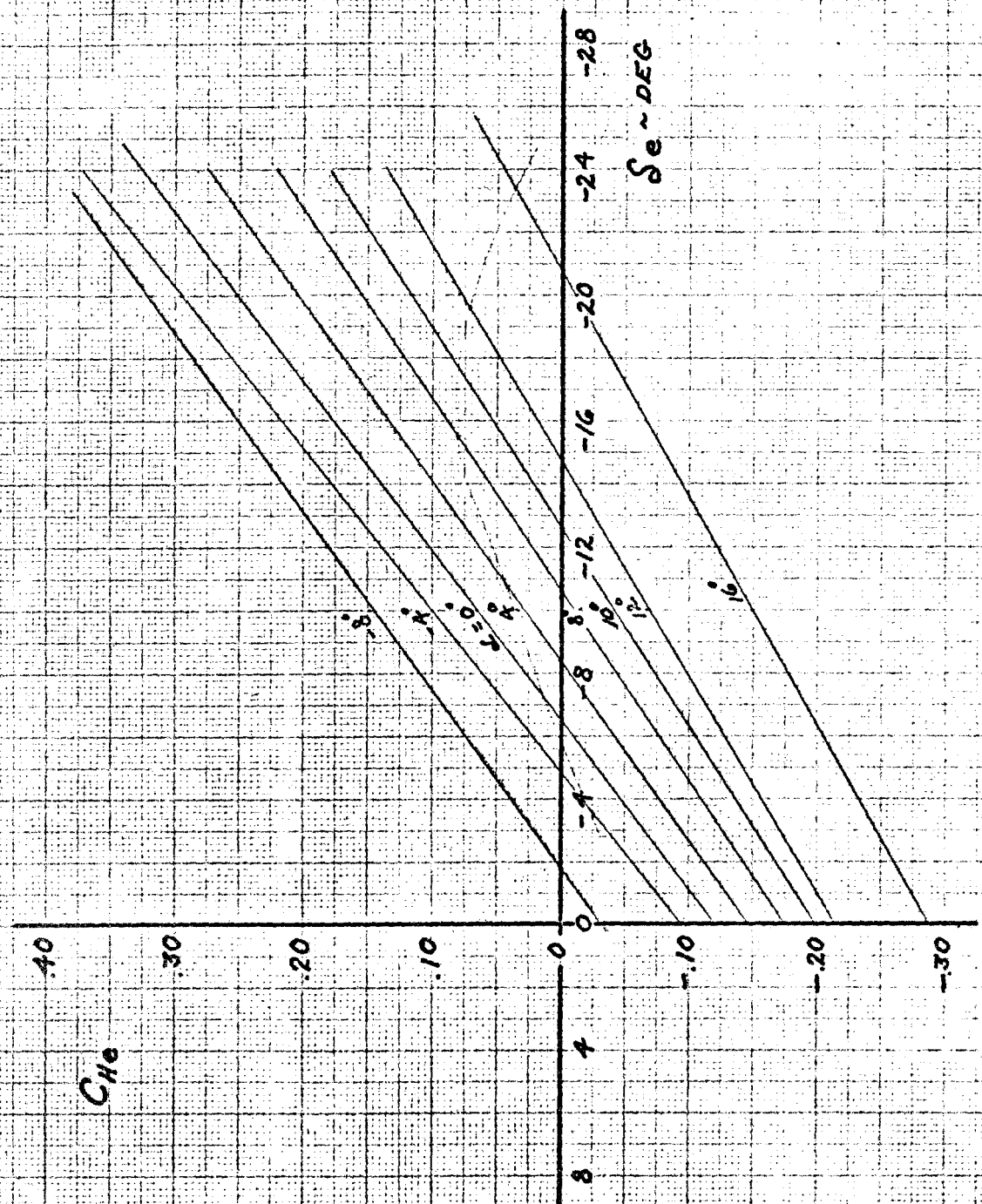


FIG. 6.7B

CALC	<i>Hand</i>	11-3-61	REVISED	DATE	EFFECT OF ELEVON DEFLECTION ON HINGE MOMENT $M = 1.40$	844-2050D
CHECK			12-20-61			D2-80065
APR						PAGE
APR						6.88
THE BOEING COMPANY						

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DYNA-SOAR MODEL 844-2050D

M = 2.0

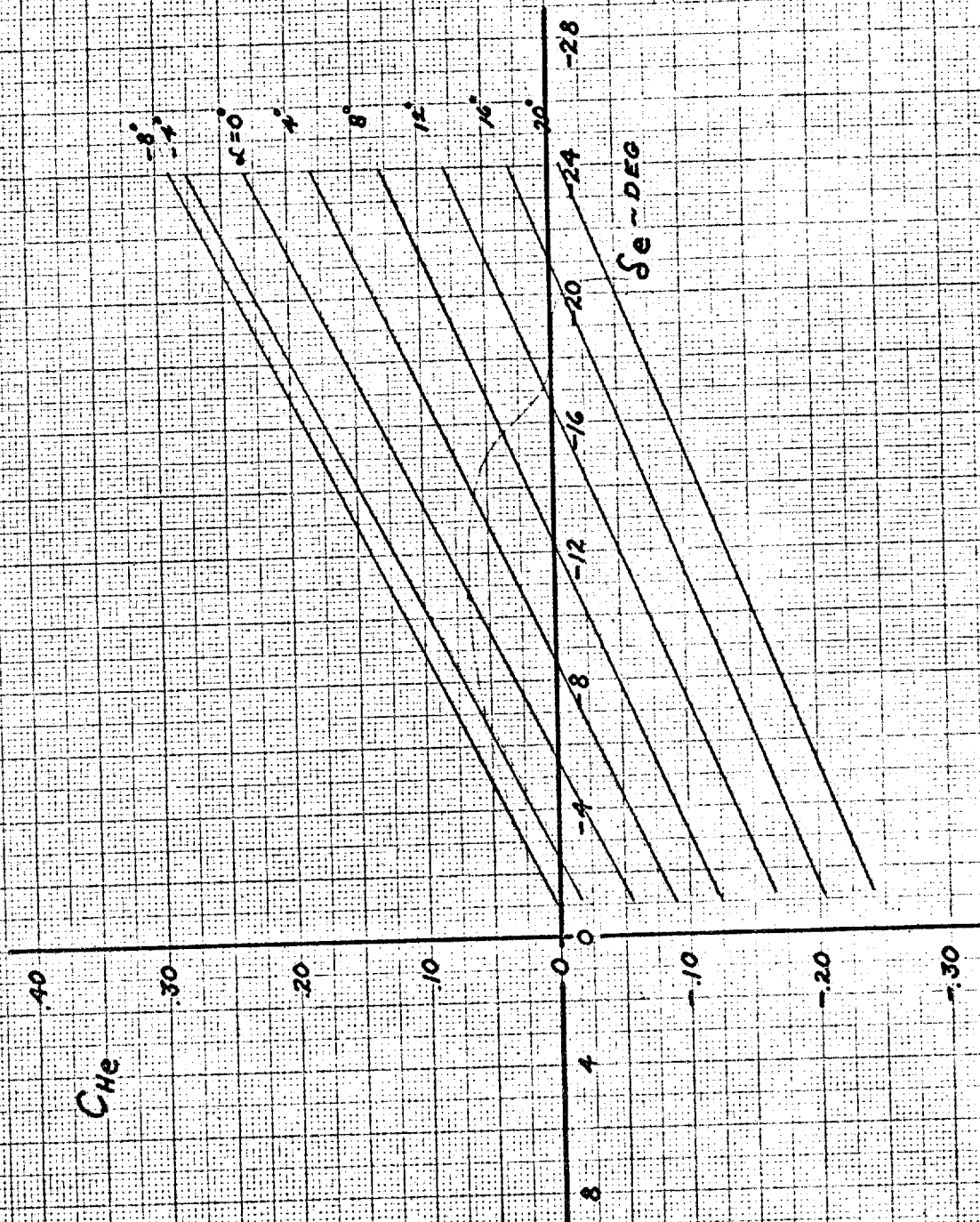


FIG. 6.79

CALC	W. G. B.	11-6-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
M = 2.00

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844-2050D

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6.19

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DYNA-SOAR MODEL 844-2050D

M = 3.5

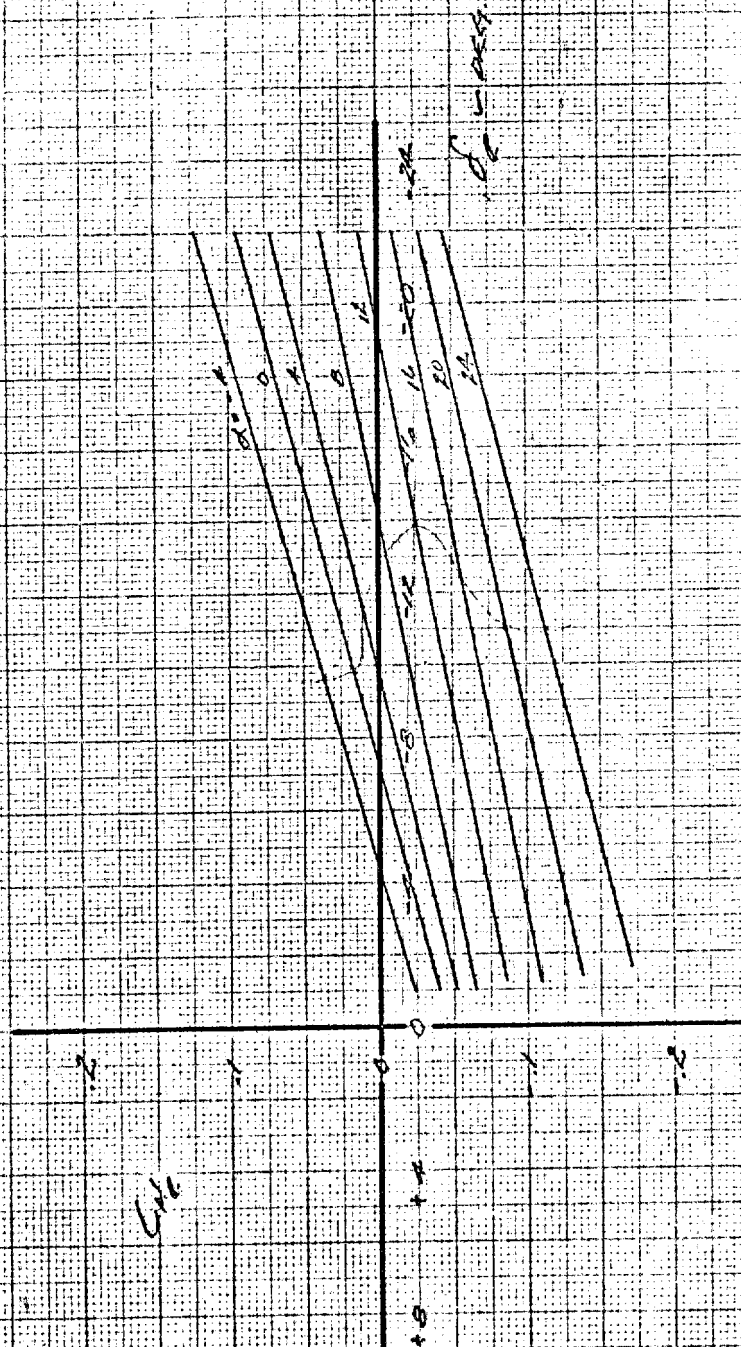


FIG. 6.80

CALC	Designed	12.1	REVISED	DATE
CHECK			12.2	1
APR				
APR				

EFFECT OF ELEVON DEFLECTION
ON HINGE MOMENT
M = 3.50

THE BOEING COMPANY

844-2050D
D2-80065
PAGE
6.90

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$M = 0.50$

C.G. AT .44 M.R.C.

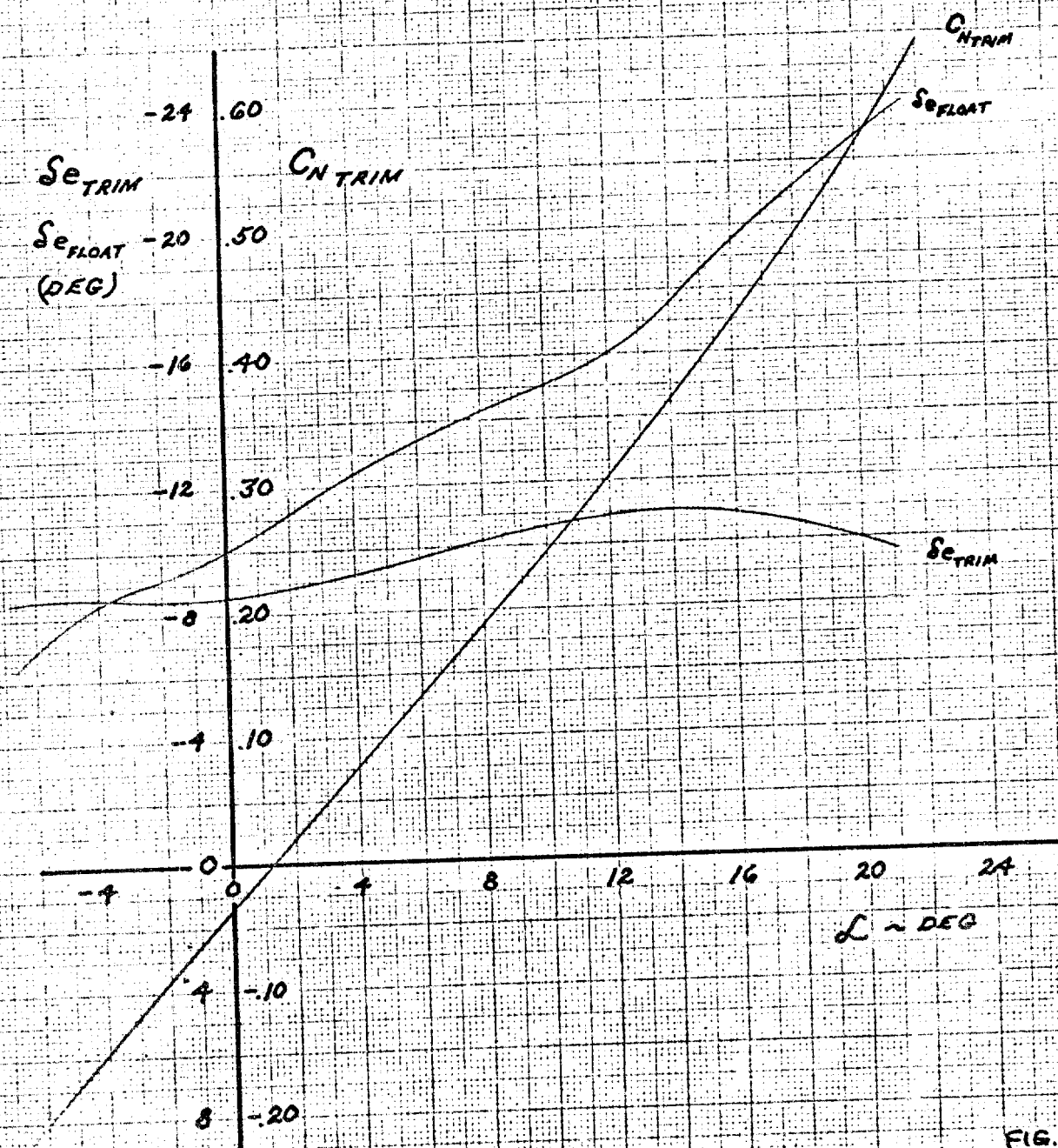


FIG. 6.81

CALC	<i>Handwritten initials</i>	11-13-61	REVISED	DATE
CHECK			12-20-1	
APR				
APR				

ELEVON FLOAT & TRIM COMPARISON
GLIDER ALONE
 $M = 0.50$

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844-2050D
02-80065
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DRAM-504K MODEL 844-2050D

$M = 0.80$

$C_{L,0} = 1.4 \text{ MAC}$

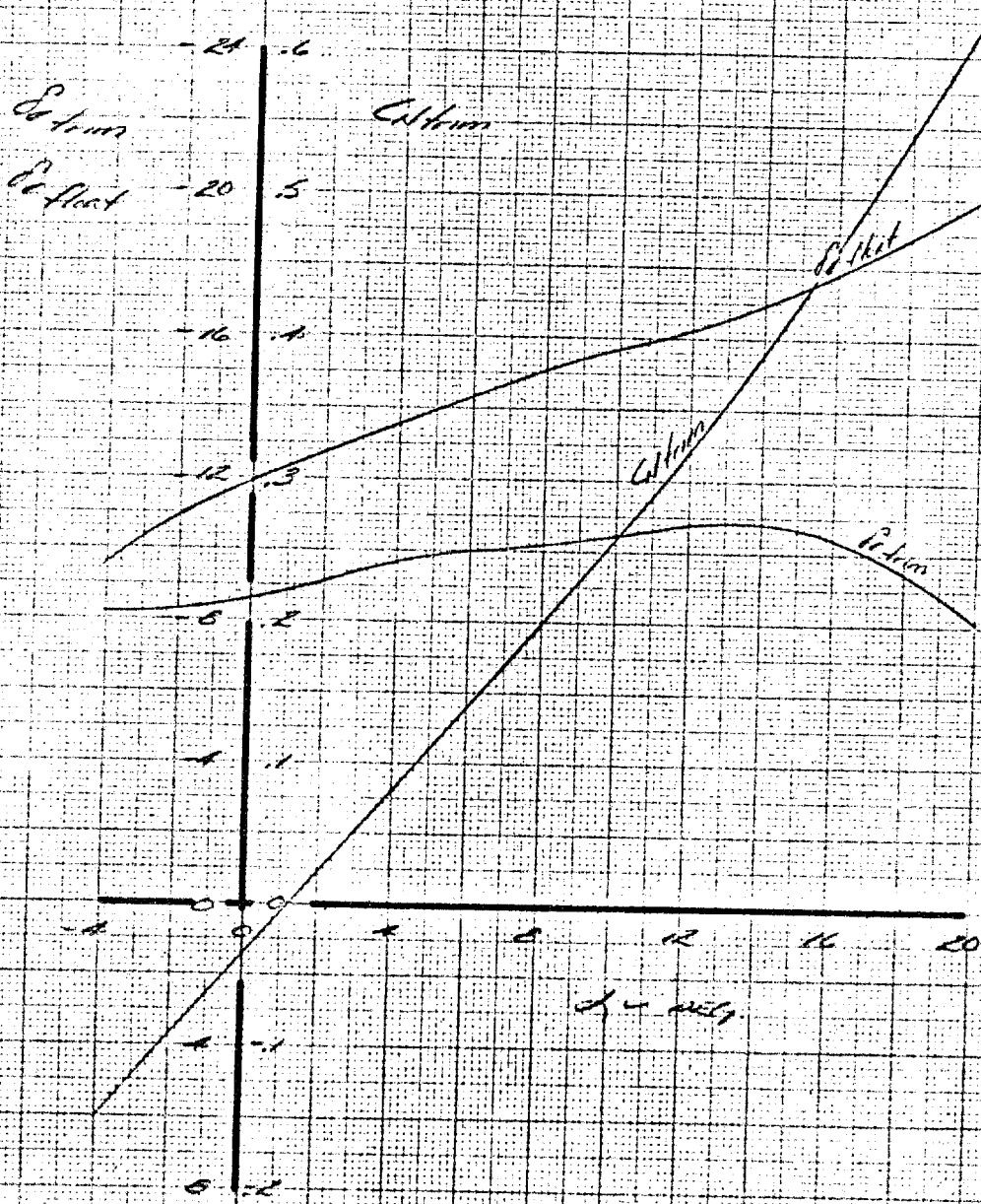


FIG. G.82

CALC	SANATH	11-12-1	REVISED	DATE
CHECK			12-20-1	
APR				
APR				

ELEVON FLOAT & TRIM COMPARISON
GLIDER ALONE
 $M = 0.80$

844-2050D

02-80065

THE BOEING COMPANY

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DATA-SKIP MODEL 844-2050D

$$M = 0.95$$

C.G. AT .44 m.q.c.

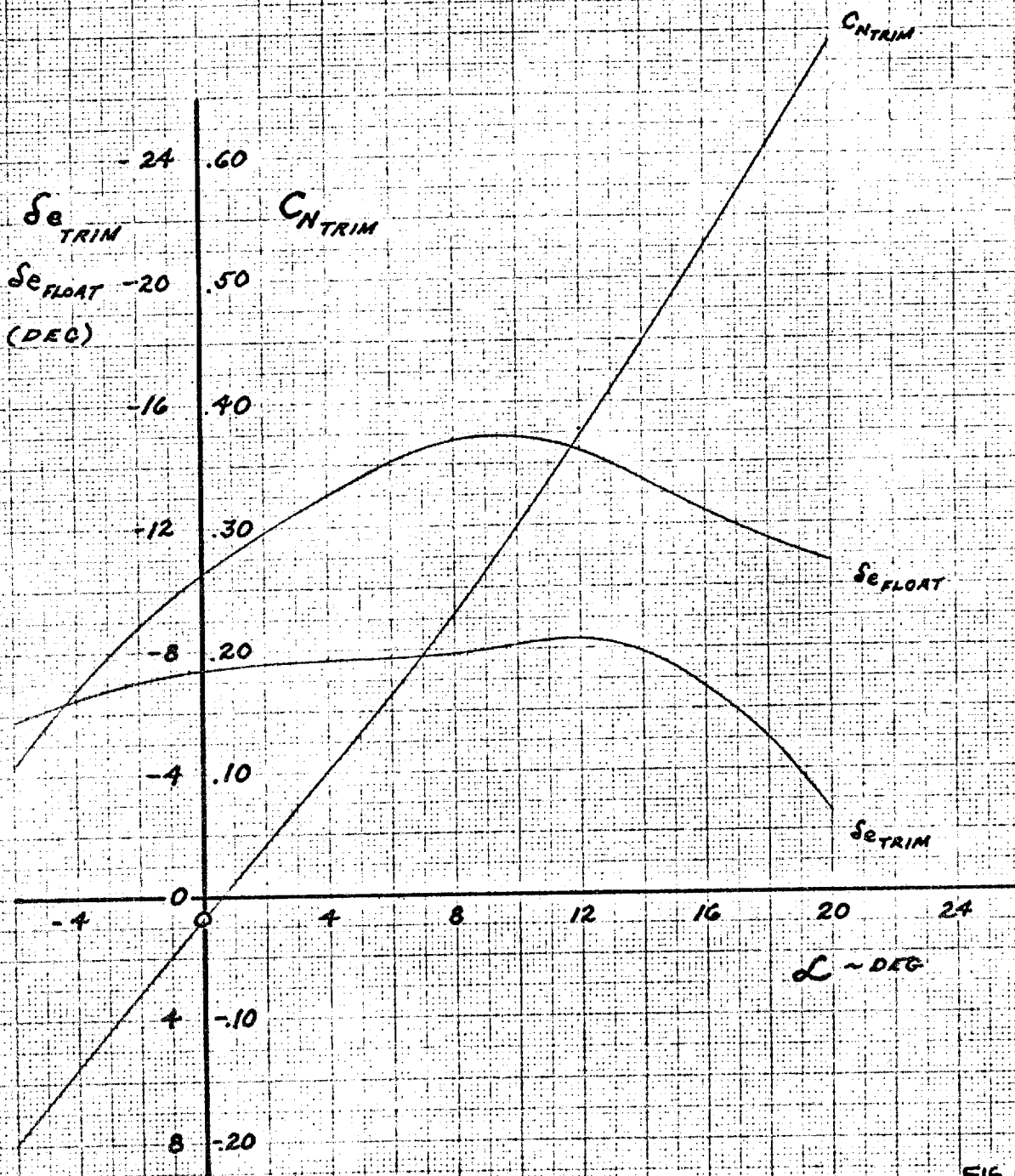


FIG. 6.83

CALC	<i>Hand Calc</i>	11-11-61	REVISED	DATE	ELEVON FLOAT & TRIM COMPARISON GLIDER ALONE $M = 0.95$ THE BOEING COMPANY	844-2050D
CHECK			12-20-61			02-80065
APR						PAGE
APR						6.93

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DATA-SOAR MODEL 844-20500

$M = 1.00$

$C.G. = 44 \text{ mac}$

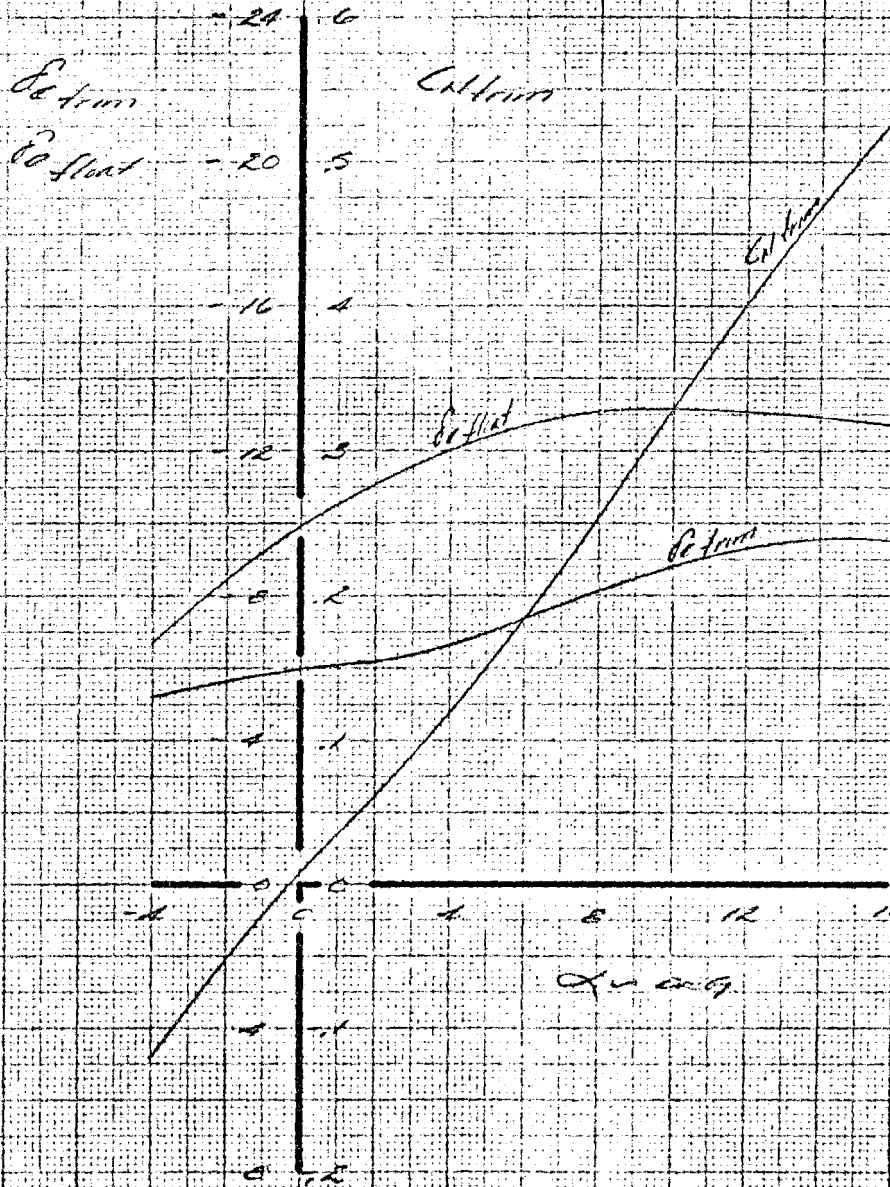


FIG. 6.84

CALC	844-20500	N. 15.1	REVISED	DATE	ELEVON FLOAT & TRIM COMPARISON GLIDER ALONE $M = 1.00$ THE BOEING COMPANY	844-20500
CHECK			12-50-1			02-80065
APR						PAGE
APR						6.94

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844-20500 844-20500

$M = 1.10$

$C.G. = 14.0$

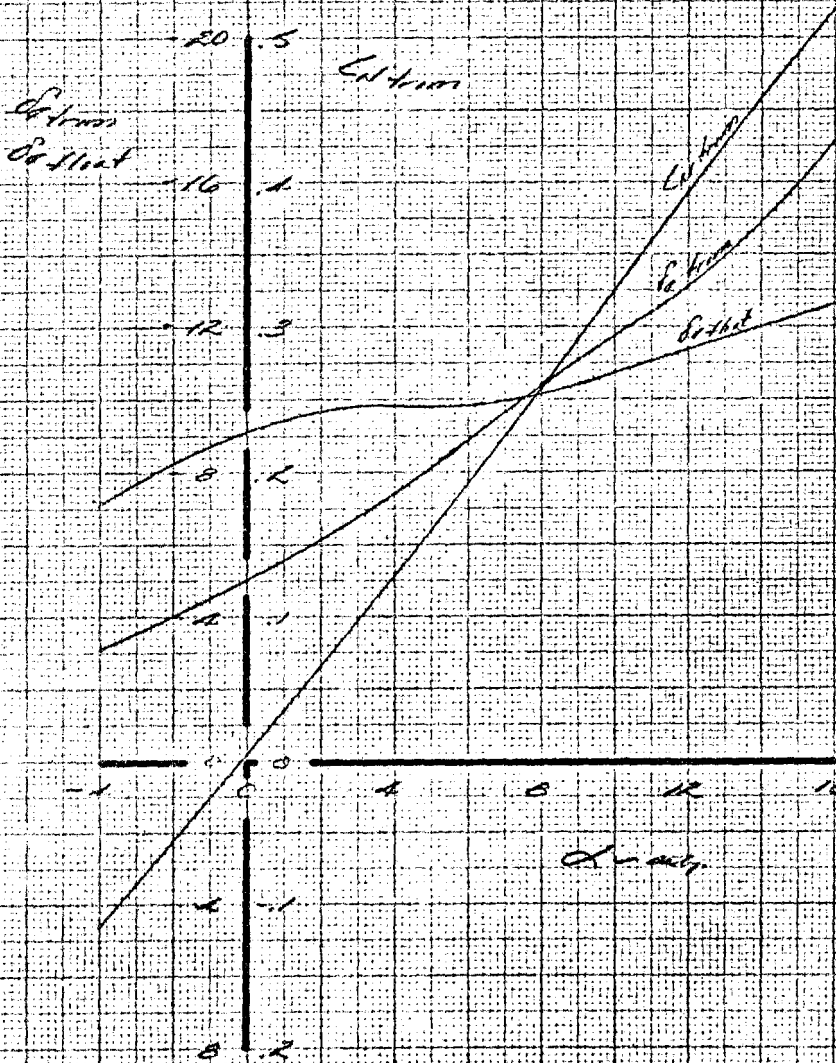


FIG. 6.85

CALC	844-20500	8.13.1	REVISED	DATE	ELEVON FLOAT & TRIM COMPARISON	844-20500
CHECK			12-20-1		GLIDER ALONE	
APR					$M = 1.10$	OR-80065
APR					THE BOEING COMPANY	PAGE
						695

DYNAL-SOAR MODEL 844-2050D

1.4

CG = 14.7 MAC

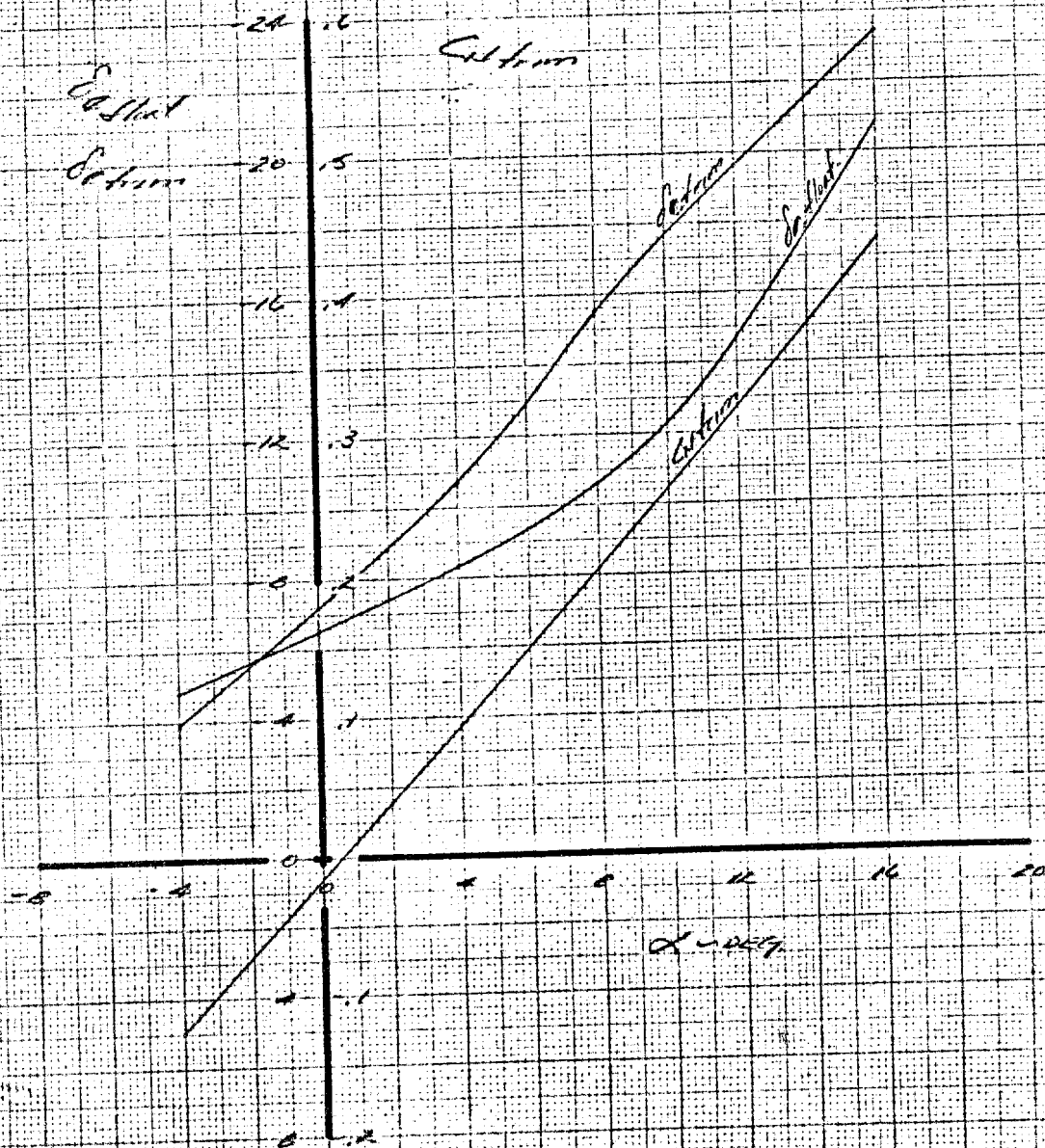


FIG. 6.86

CALC	SIMARI	M. P. 1	REVISED	DATE	ELEVON FLOAT & TRIM COMPARISON GLIDER ALONE M = 1.40	844-2050D
CHECK			12-2-1			DL-80065
APR						
APR					THE BOEING COMPANY	PAGE 6.96

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DYNA-SUR MODEL 844-20500

$M = 2.0$

C.G. AT .44 m.q.c.

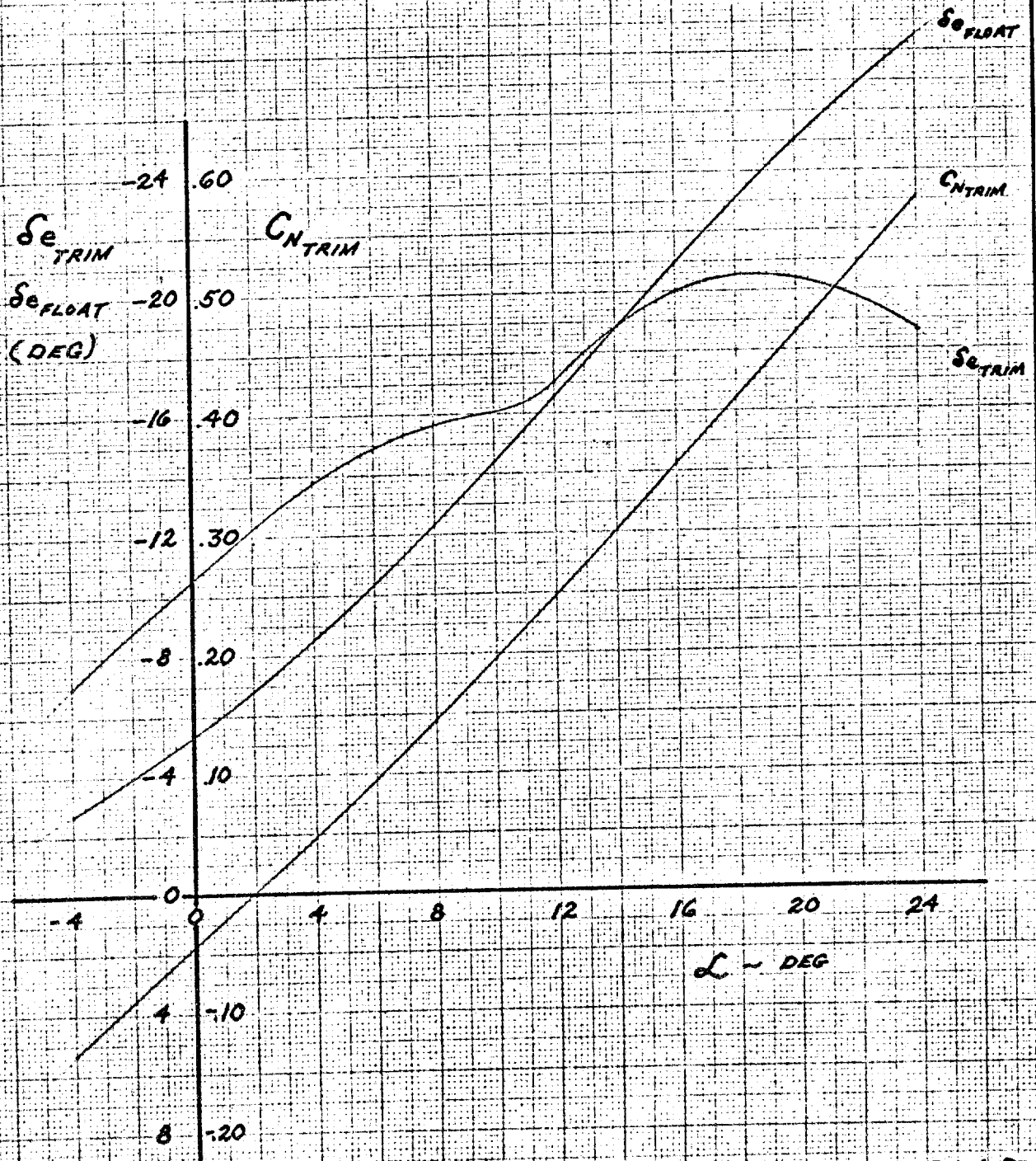


FIG. 6.87

CALC	<i>Wp. a.c.</i>	11-11-61	REVISED	DATE
CHECK			12-20-61	
APR				
APR				

ELEVON FLOAT & TRIM COMPARISON
GLIDER ALONE
 $M = 2.00$

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PAGE
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DATA - 30416 (10001) - 20500

$$M = 3.5$$

C.G. AT .44 m.a.c.

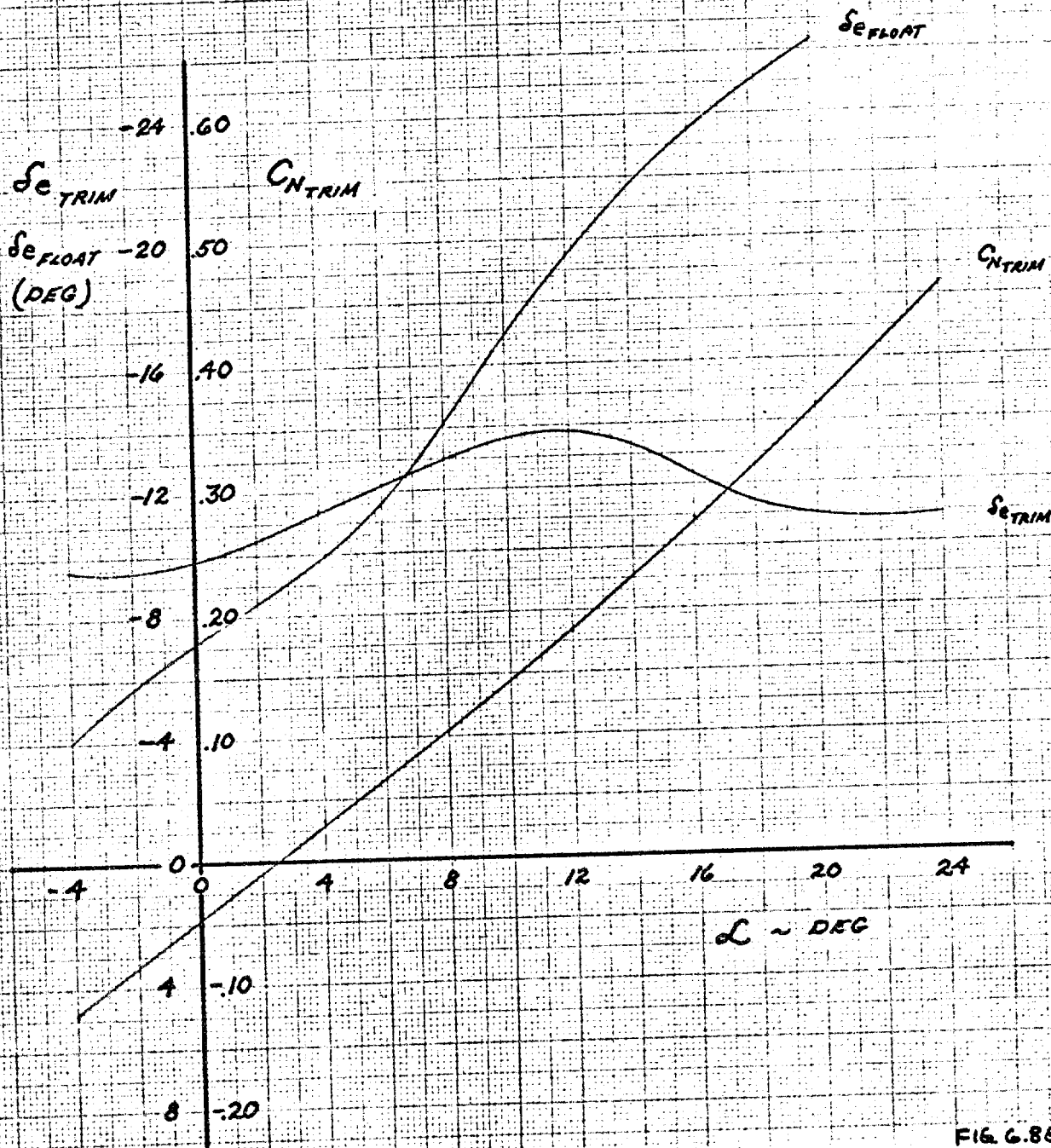


FIG. 6.88

CALC.	2/2/61	11-9-61	REVISED	DATE	ELEVON FLOAT & TRIM COMPARISON GLIDER ALONE M = 3.50	844-20500
CHECK			12-27-61			02-80065
APR						PAGE 6.98
APR						
THE BOEING COMPANY						
Approved For Release 2003/10/15 : CIA-RDP70B00584R000200010001-1						ALBANESE 1981 DATE

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CONFIDENTIAL**6.2 LATERAL-DIRECTIONAL STABILITY AND CONTROL**

Lateral-directional stability and control characteristics for model 844-2050 D glider configuration are presented in Figures 6.89 through 6.97. All data shown are for a rigid glider with the c.g. at .44c and waterline 124. Aeroelastic effects are given in section 8. Figures are shown with the elevons in longitudinal trim position, except for the aileron characteristics where symmetric deflections from the trim position have been considered. Summary Mach number curves of directional aerodynamic center, directional stability, lateral stability and side force derivative are shown in Figures 6.89-6.92. Lateral-directional control characteristics, yawing and rolling moment variation with rudder or aileron deflection, are shown in Figures 6.93 through 6.97. At individual Mach numbers, lateral-directional characteristics have been presented versus sideslip angle to show existing non-linearities. More detail of the incremental effects of rudder or aileron deflections has also been shown at constant Mach numbers. Rudders are deflected about a 6 degree trail position below a Mach number of 2.5 and about a position faired with the vertical at higher Mach numbers. Both rudders are deflected simultaneously between limits of 12 degrees inboard and 35 degrees outboard.

Curves are based on wind tunnel data and analytical estimates. Subsonic and transonic data were obtained in the Boeing Transonic Wind Tunnel, while supersonic data came from tests in the Boeing Supersonic Wind Tunnel. Jet Propulsion Laboratory 21" Hypersonic Wind Tunnel and Arnold Center Tunnel B provided the hypersonic data. Consideration was also given to previous high Mach number data from Boeing Hot Shot Wind Tunnel on a similar glider configuration.

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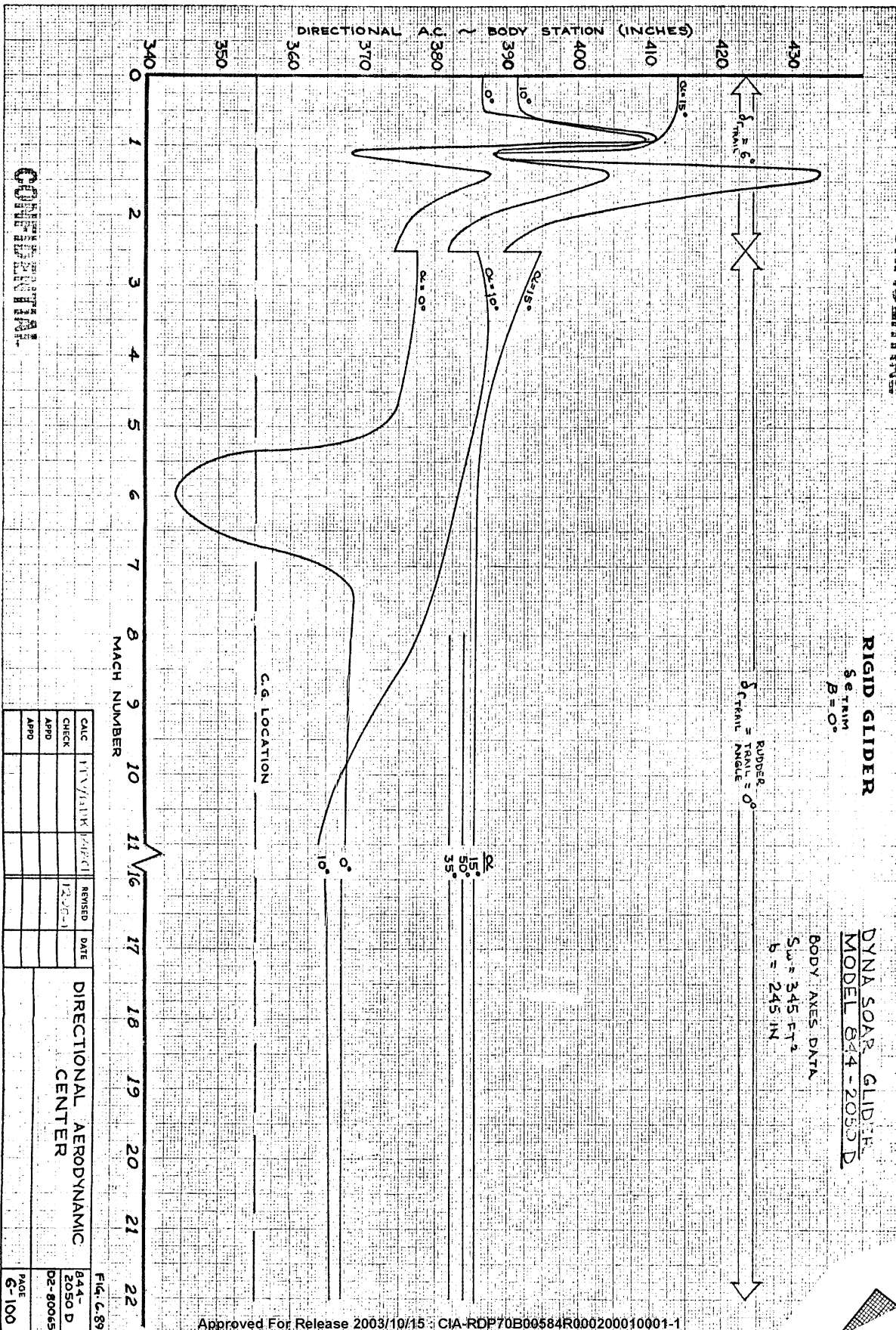
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RIGID GLIDER

$\delta_{\text{TRIM}} = 0^\circ$
 $\beta = 0^\circ$

DYNA SOAR GLIDER
MODEL 844-2050 D
BODY AXES DATA
 $S_w = 345 \text{ FT}^2$
 $b = 245 \text{ IN}$

RUDDER
 $\delta_{\text{TRAIL}} = 0^\circ$



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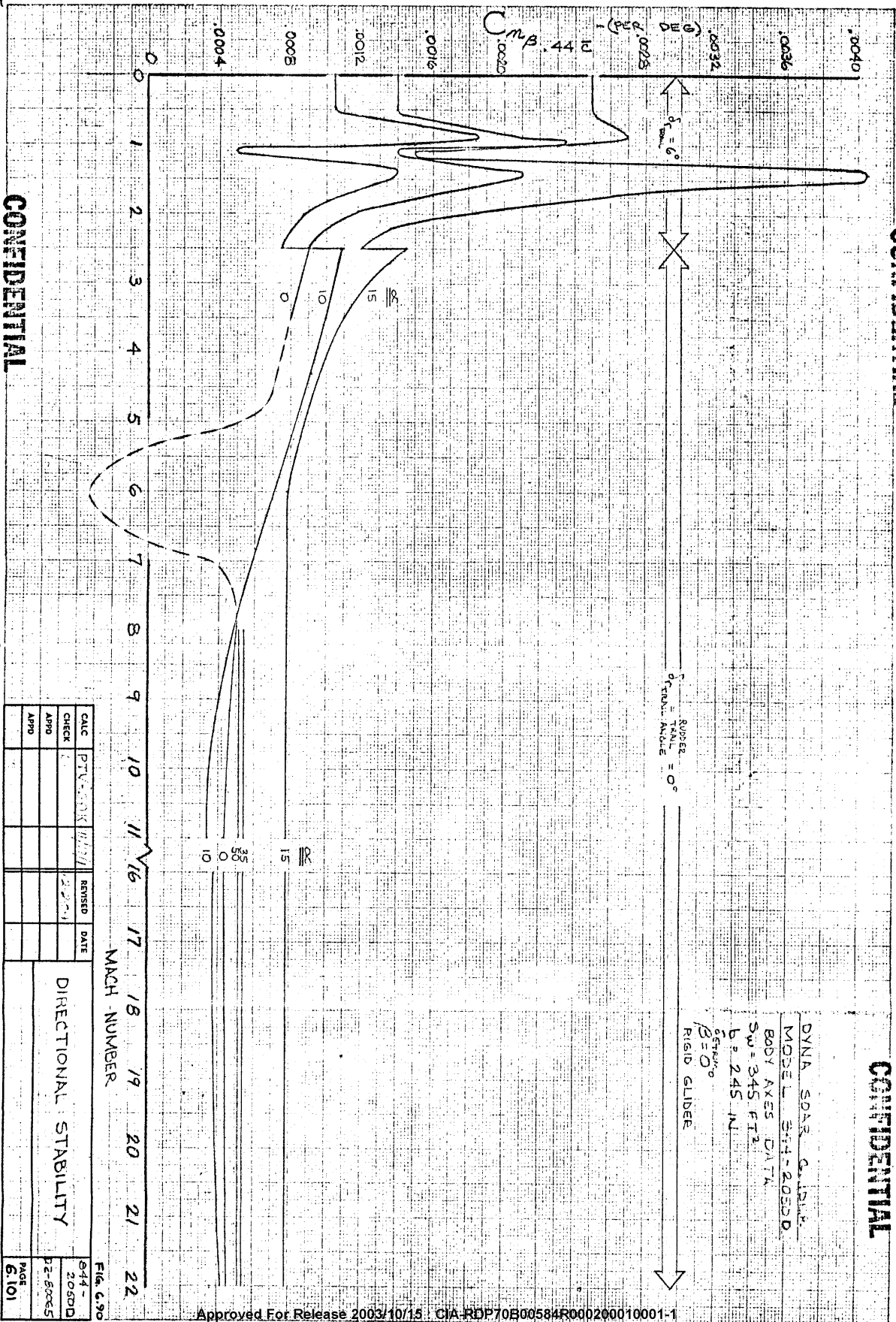
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CALC	CHK	REVISED	DATE
CHK			
APPD			
APPD			

DIRECTIONAL STABILITY

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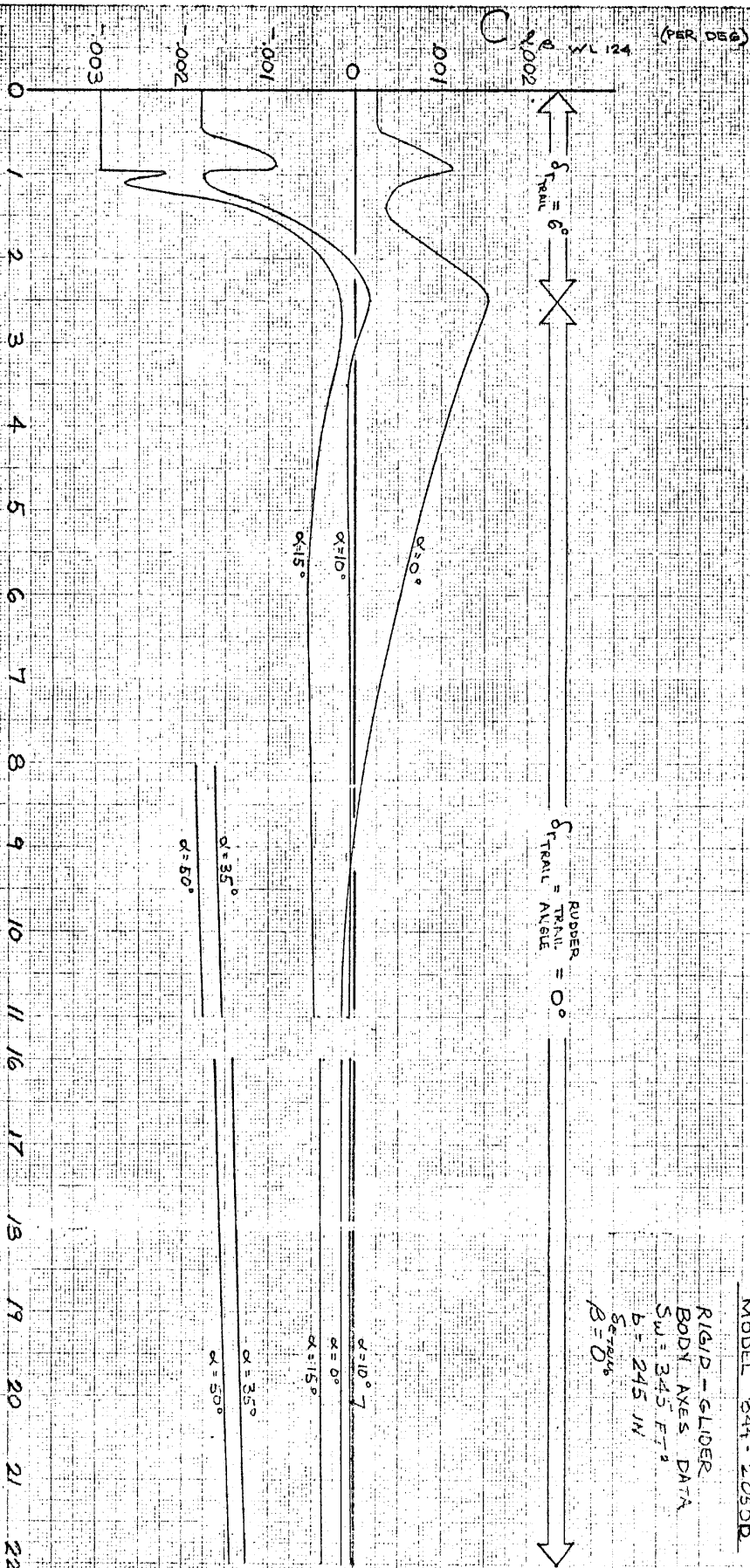
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DYNA SOAR GLIDER
MODEL 844-2050D

RIGID - GLIDER
BODY AXES DATA
SW = 345 FT²
b = 245 IN
 $\delta_{\text{TRAIL}} = 0^\circ$
B = 0



MACH NUMBER

CALC	PTV	11/7/71	REMOVED	DATE	LATERAL STABILITY
CHECK			12-20-71		
APPRO					
APPRO					
					FILE 6.91
					B-44-2050D
					D2-60065
					PAGE 6.102

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US 4041 7000

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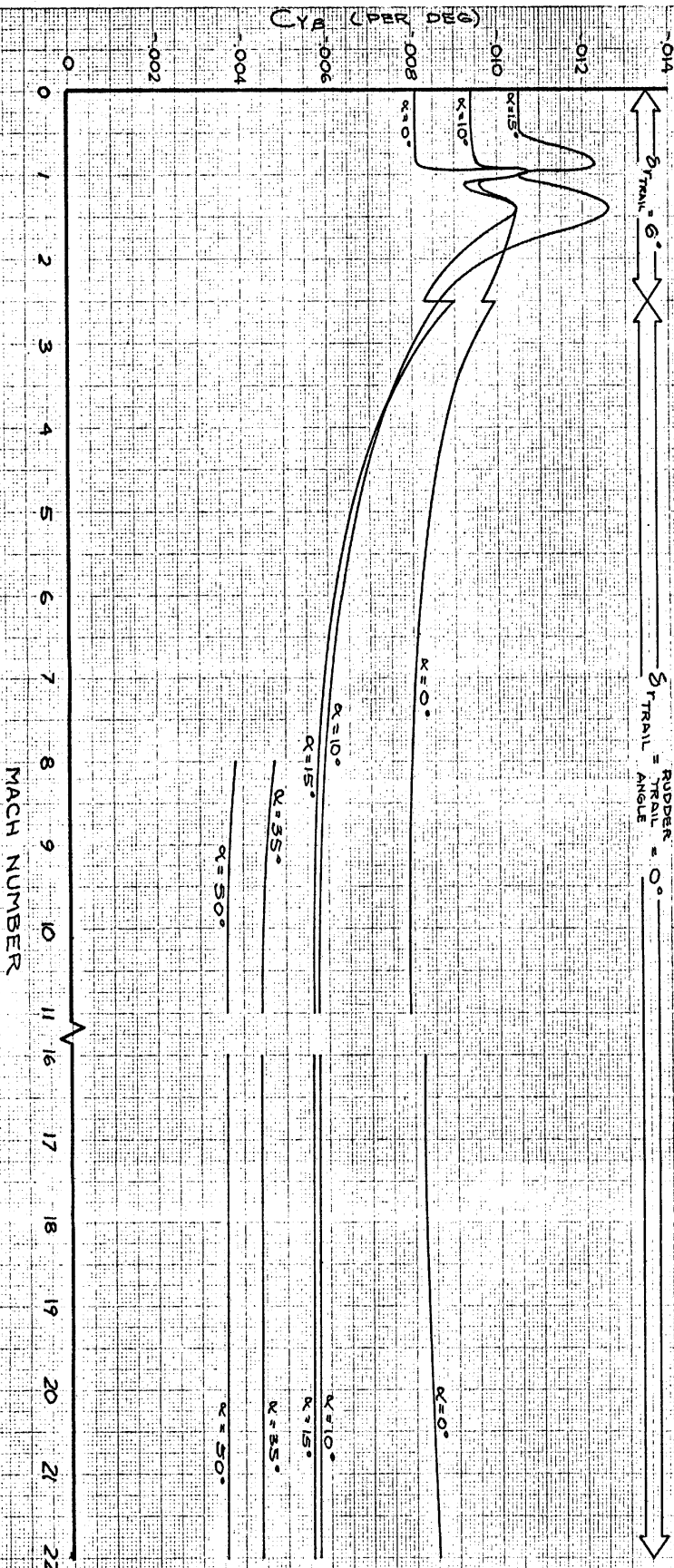
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DYNA SOAR GLIDER
MODEL B44-2050D

RIGID
 $S_w = 345 \text{ ft}^2$
 $b = 245 \text{ in}$
RIGID GLIDER
 $\beta = 0^\circ$
SETBACK



MACH NUMBER

CALC	PTV	11/21/11	REVISED	DATE
CHECK				
APRD				
DRN	RICE	11-21-11		

SIDE FORCE DERIVATIVE

FILE 691
044-2050D
DE-50365
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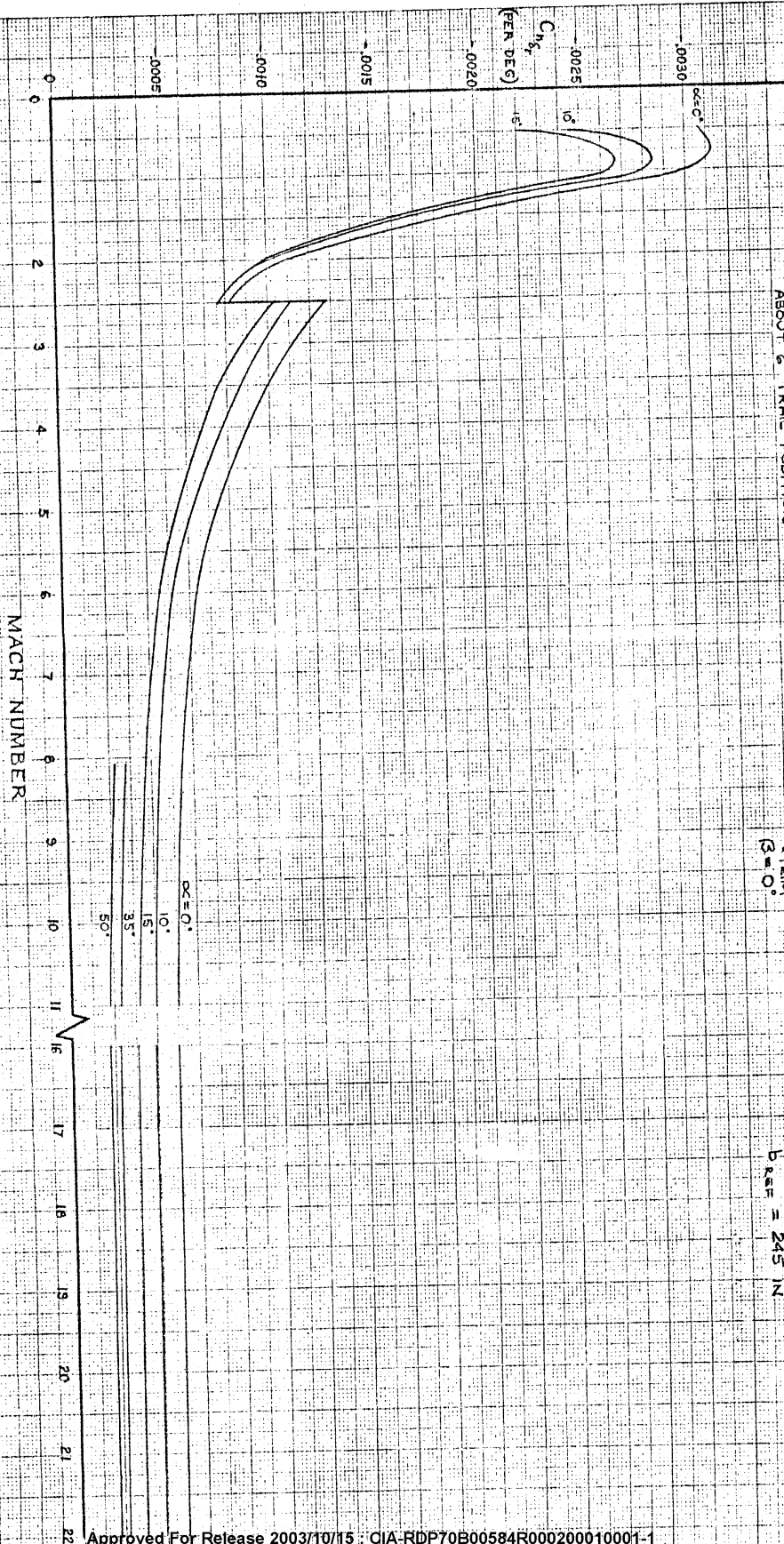
NOTE: M < 2.5 RUDDERS DEFLECTED
ABOUT 6° TRAIL POSITION

RIGID GLIDER

DETERMINE
 $B = 0^\circ$

DYNA SOAR GLIDER
MODEL 844 - 2050D

$$S_{wref} = 345 \text{ FT}^2$$

$$b_{ref} = 245 \text{ IN}$$


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SECRET

DATE	P-W/EXH	REVISED	DATE	RUDDER EFFECTIVENESS ~ YAWING MOMENT	544-1 2650 D 02-90808 6-104
CHECK					
APPRO					
APPRO					

F16g. C.93

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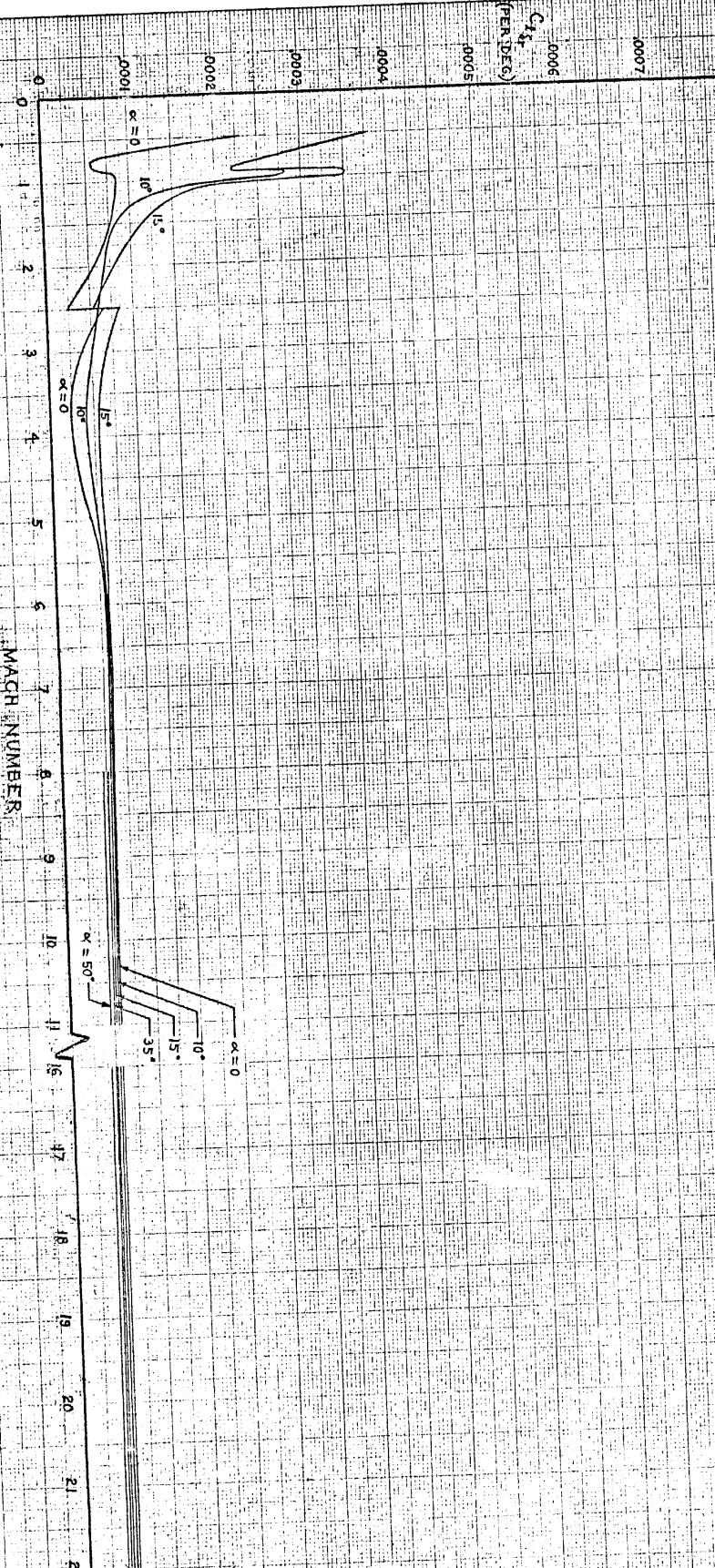
**DYNA SOAR GLIDER
MODEL 844-2050D**

RIGID GLIDER

$\delta = 0^\circ$

$S_{WING} = 345 \text{ FT}^2$
 $b_{REF} = 245 \text{ IN}$

NOTE: M2.5 RUDDERS DEFLECTED
ABOUT 6° TRAIL POSITION



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RUDDER EFFECTIVENESS
ROLLING MOMENT

FIG. 694
2050D
DS-8005
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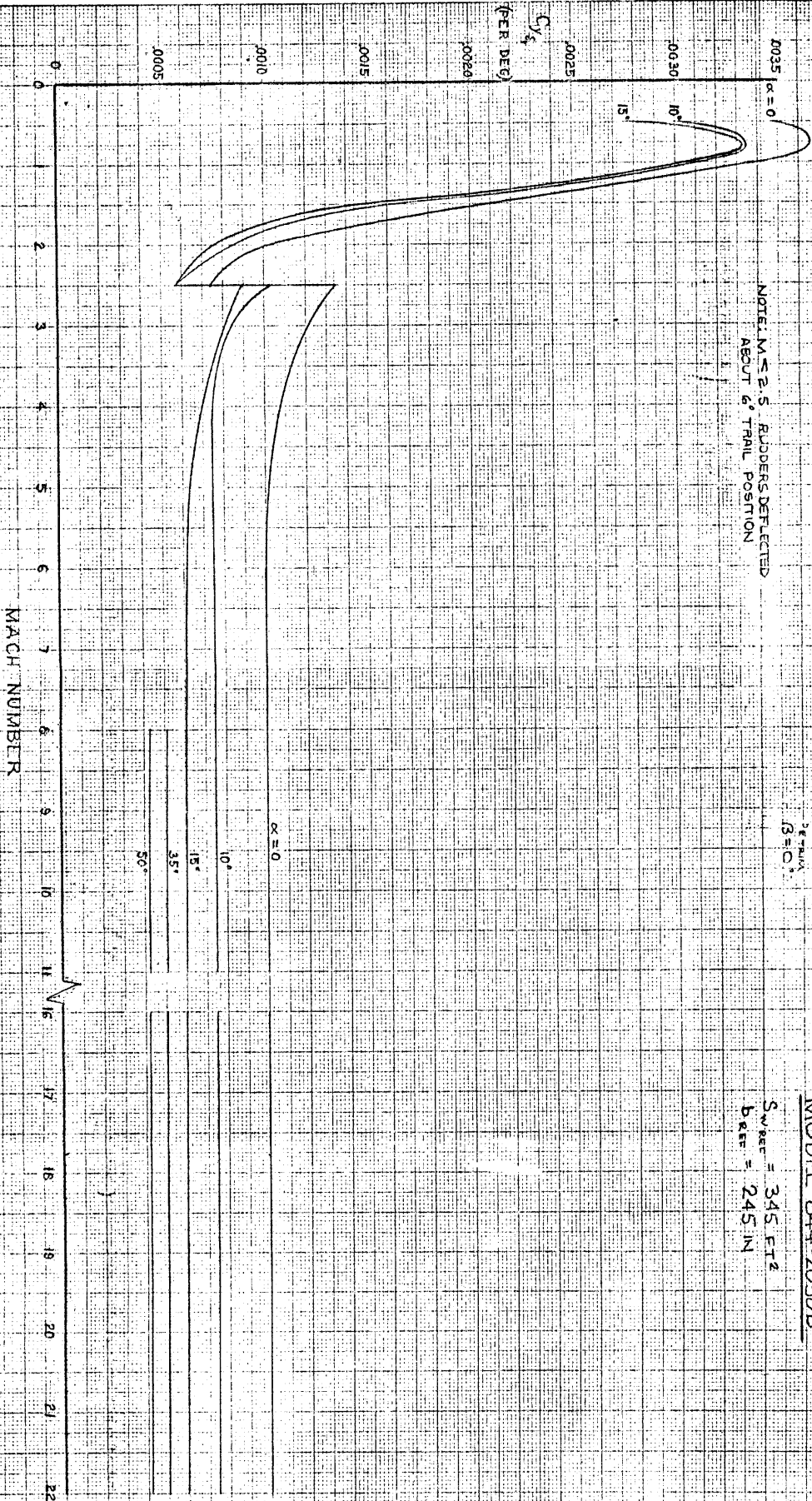
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RIGID GLIDER

DYNA SOAR GLIDER
MODEL 844-2050D

$S_{wref} = 345 \text{ FT}^2$
 $b_{ref} = 245 \text{ IN}$

NOTE: M 52.5 RUDDERS DEFLECTED
ABOUT 6° TRAIL POSITION



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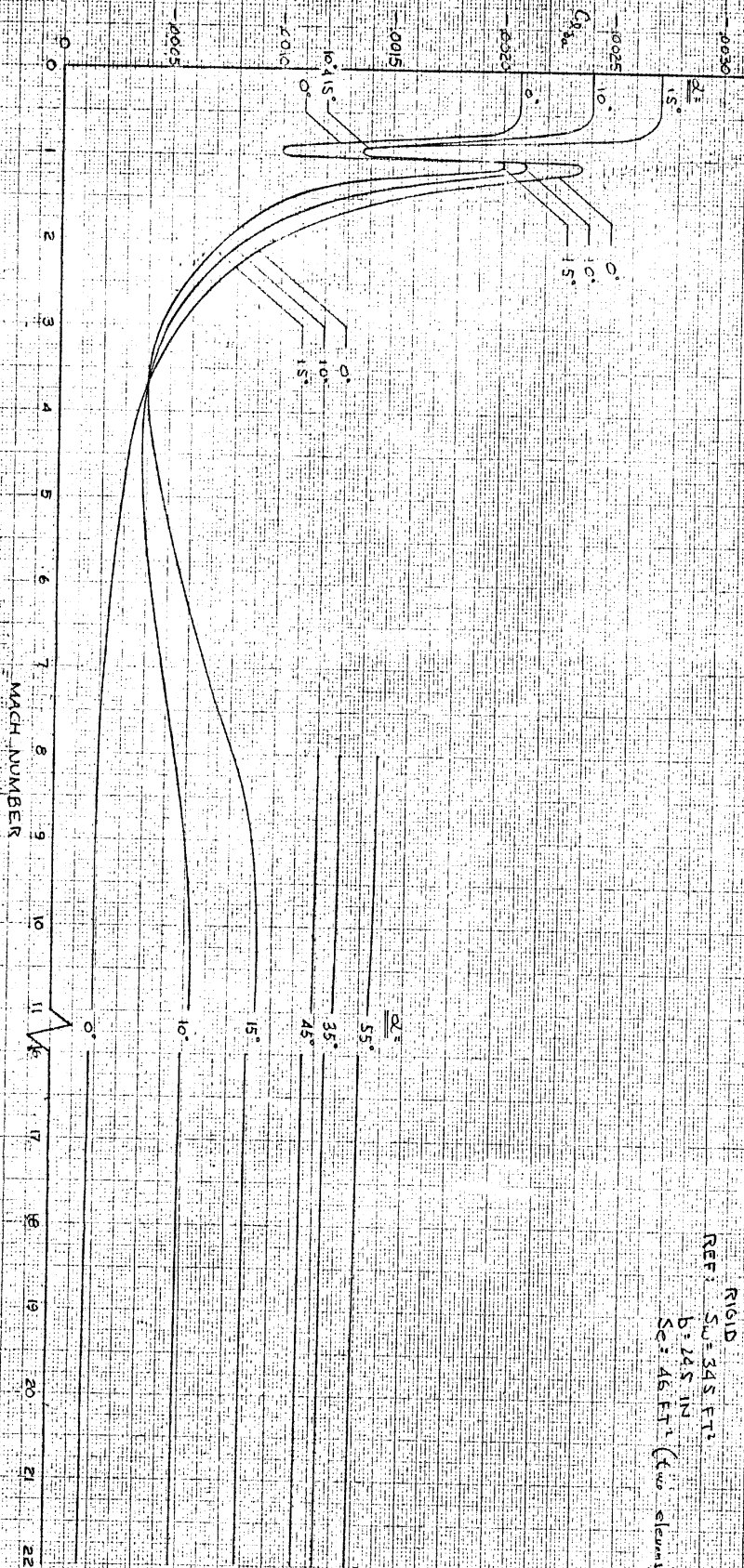
CALC	PVT/EMP	REVISD	DATE	RUDDER EFFECTIVENESS ~ SIDE FORCE DERIVATIVE	FIG. 6.95
CHECK		17-2-64			844-2050D
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APPRO					PAGE 6.106

US 4041 7000 (WAS BAC 1033.11)

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AIRCRAFT EFFECTIVE PRESSURE
ROLLING MOMENT

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DYNAB-SOAR

MODEL 1844-2050D

BODY AXES

Frigo 10

REF: 33-345 ETT

$$p = 24 \leq 25$$

CC-7671-1 (Case E150003)



MACH LUNGEER

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6.2.1 LANDING SPEED - GEAR AND GEAR DOORS EXTENDED

The stability characteristics as shown on Figure 6.78 are based on wind tunnel data for gear only from test BTWT 634, on glider data from test BTWT 682 and BTWT 685 and on calculation for gear doors extended for the 844-2050 D rigid glider. Test data for the complete built up configuration of 844-2050 D glider with gear and gear doors extended will be obtained in the near future.

Aileron characteristics and rudder effectiveness will be covered under Lateral Directional Subsonic and Transonic Speed 6.2.2.

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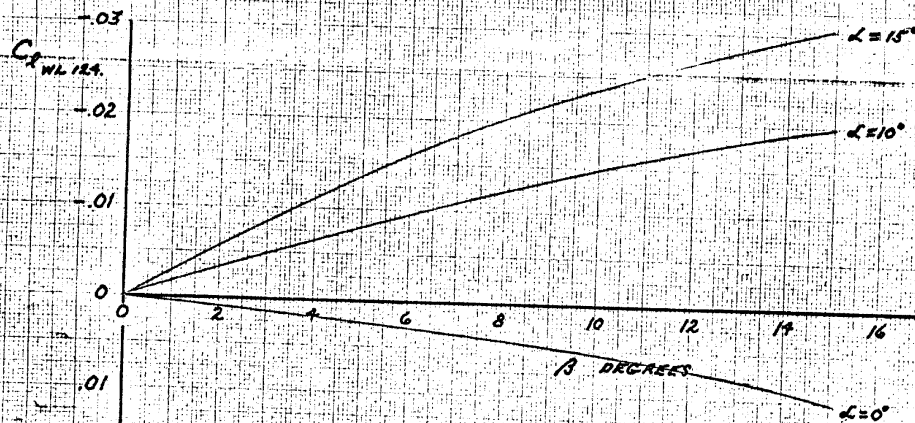
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1. The first part of the document is a list of names and their corresponding addresses. The names are listed in the left column, and the addresses are listed in the right column. The names are: John Doe, Jane Smith, and Bob Johnson. The addresses are: 123 Main St, 456 Elm St, and 789 Oak St.

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ALABAMA POWER



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APPRO					

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6.2.2 SUBSONIC-TRANSONIC SPEED

Presented in this section are lateral directional stability, rudder effectiveness and aileron characteristics for the 844-2050 Revision D glider through the subsonic-transonic speed range.

Glider stability is shown in plots of C_n , C_y and C_l vs β in figures 6.101 through 6.103 at Mach numbers of .50, .80, .95, 1.0 and 1.10 for an elevon deflection of -10° . These data are based on Boeing transonic wind tunnel test 685 and modified for the Revision D configuration.

Figures 6.104 through 6.108 present rudder effectiveness for an elevon deflection of -10° at Mach numbers of .50, .80, .90, .95 and 1.10. The data are shown as C_n , C_y and C_l vs δ_r and are based on Boeing transonic tests 672 and 682. Dual rudder characteristics are shown in figures 6.104 through 6.108 and are representative of normal in-flight rudder operation. Figures 6.109 through 6.113 present the single rudder characteristics upon which the dual rudder data is based. The single rudder data may be used to determine rudder effectiveness at any initial rudder angle.

Aileron characteristics, C_n , C_y and C_l vs δ_a are shown in figures 6.114 through 6.117 for Mach numbers of .50, .80, .95 and 1.10. These data represent elevon deflections of -10° to -15° and are based on Boeing transonic test 672.

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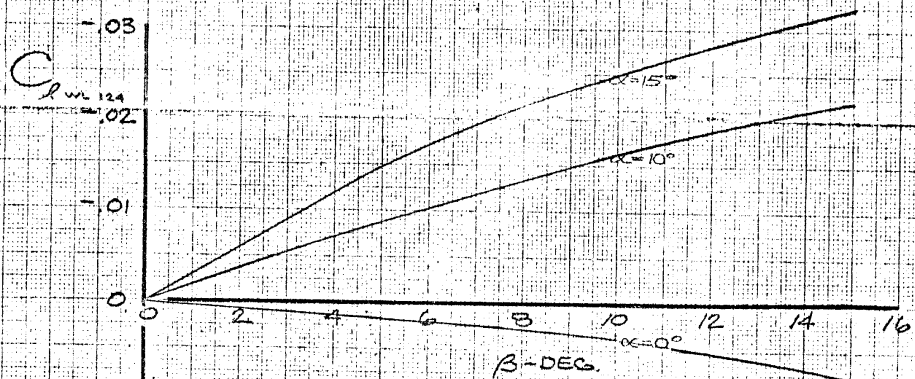
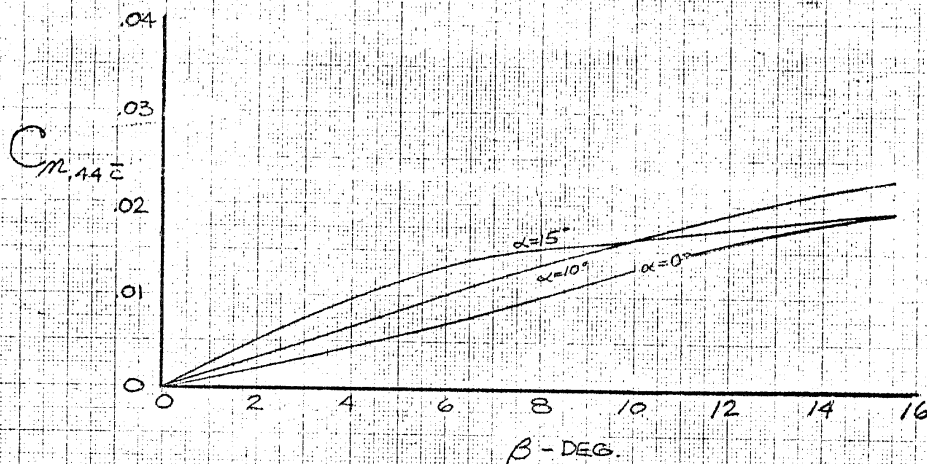
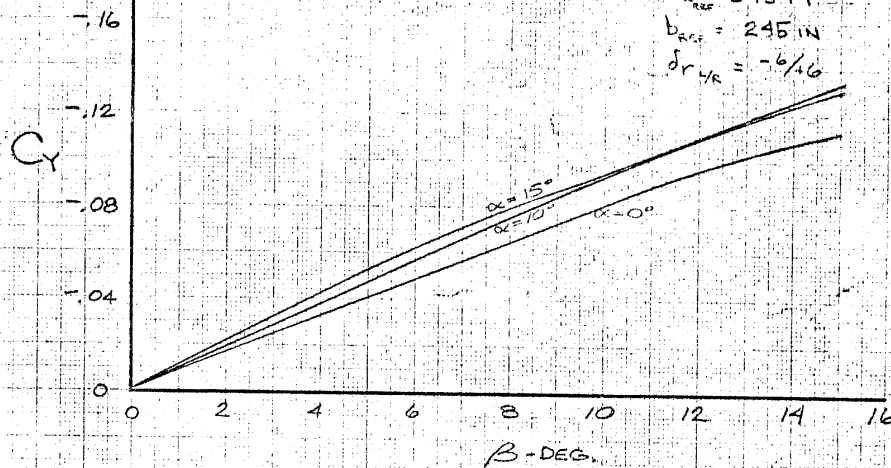
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$M = 0.50$

DYNA SOAR
MODEL 844-2050D

BODY AXES
RIGID
 $S_w = 345 \text{ FT}^2$
 $b_{ref} = 245 \text{ IN}$
 $\delta r_{1/2} = -6/16$

$\delta \epsilon = -10^\circ$



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APPRO				

LATERAL-DIRECTIONAL STABILITY
 $M = 0.50$

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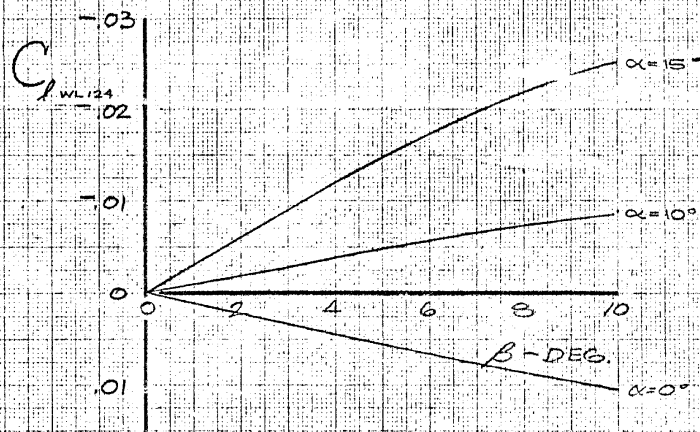
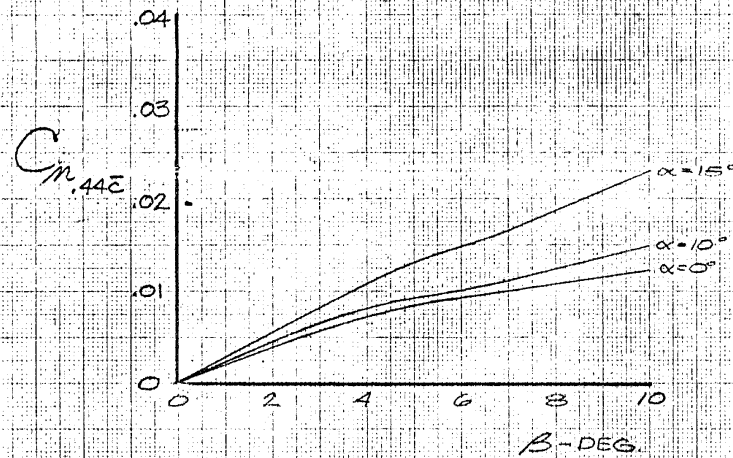
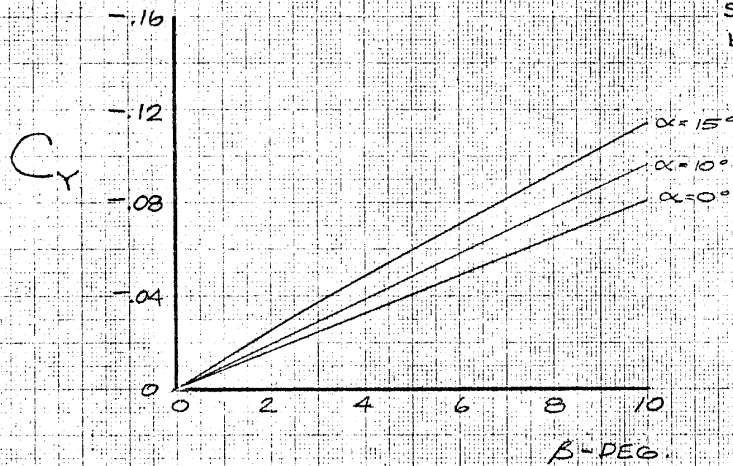
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$M = 0.90$

$\delta_e = -10^\circ$

DYNA SOAR
MODEL 844-2050 D

BODY AXES
RIGID
 $S_{WREF} = 345 \text{ FT}^2$
 $B_{REF} = 245 \text{ IN}$
 $\delta_{CYR} = -6/46$



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LATERAL-DIRECTIONAL STABILITY	
$M = 0.90$	
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